JOURNAL

VOLUME 13, NUMBER 12 • DECEMBER, 1957

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SPE 14th Technical Conference

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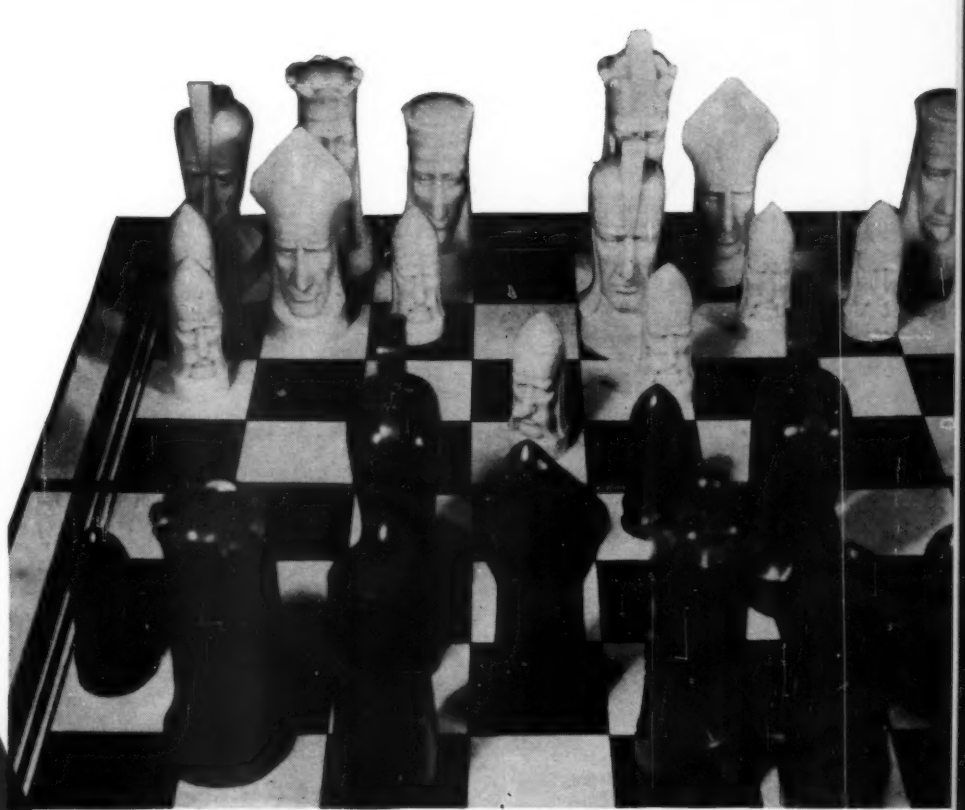

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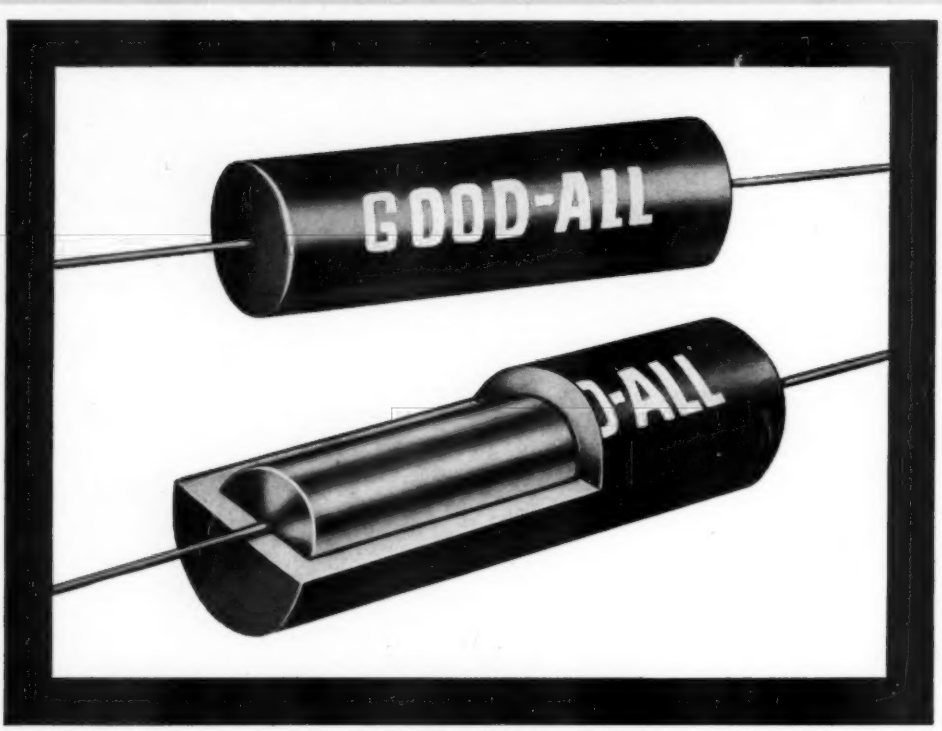

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Vol. II, No. 6

POLYETHYLENE PROCESSING TIPS

RESIN PROPERTIES THAT AFFECT STRESS-CRACK RESISTANCE OF POLYETHYLENE

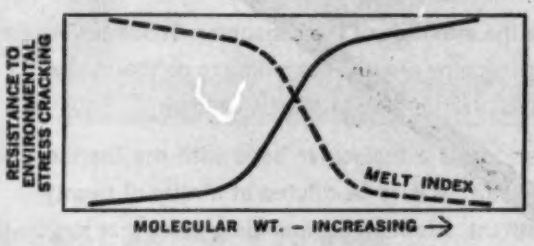
Environmental stress cracking is the term used to describe a certain type of material failure. With polyethylene this failure occurs when the plastic is under high local stress (either external or internal) and in contact with materials such as a soap, detergent, or solvent, which affects the polymer.

Resistance to stress cracking is especially important for applications such as electrical insulation, polyethylene pipe, housewares, and certain types of packages.

Two factors influence the resistance of a polyethylene part to environmental stress cracking: the resin used and the conditions used in fabricating the part.

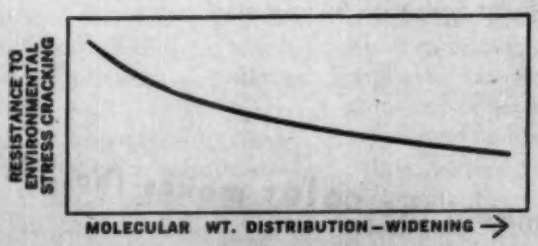
Which resin to use:

Stress crack resistance is greater with a resin of *higher molecular weight* – that is, lower melt index.



Then why not use low melt index resins? Because production rates are lower. The processor must make a compromise between peak production rate and top stress-crack resistance and use a resin that will be satisfactory, if not ideal, in both respects.

Molecular weight distribution of the polyethylene



resin is important too. Resins with a narrow molecular weight distribution (with fewer molecules much higher or lower than the average) have better stress crack resistance than those with wide molecular weight distribution (more of the larger and smaller molecules but the same average). The low molecular weight fraction is more susceptible to attack by environmental materials.

However, the flow properties of a polyethylene resin having a narrow molecular weight distribution and a given melt index are not as good as those of a polyethylene resin having a wide molecular weight distribution and the same melt index. Here again the processor must make a compromise between production rate and the properties he requires in the end product.

Density of the resin will also have an effect on the resistance of that polyethylene resin to environmental stress cracking. The higher the density, the poorer resistance to environmental stress cracking. On the other hand, the more linear or more dense polyethylenes have enhanced flow properties and higher stiffness and tensile strength.

There is no single answer to all problems

It is obvious from the preceding discussion that there is no simple solution to the selection of a resin for a particular end use. The resin must be carefully selected while giving proper consideration to the important end properties required in the fabricated article.

An answer to your particular problem can be found by obtaining a polyethylene resin from a manufacturer who can give you the balance of properties required – high or low melt index, narrow or wide molecular weight distribution, a range of densities. U.S.I. is one such supplier and their Technical Service Representatives stand ready to assist you in the selection of the proper Petrothene resin.

Processing conditions affect stress crack resistance

Processing temperatures, cooling rates, and other processing conditions can have a marked effect on stress crack resistance, because of residual strains left in the fabricated article.

There isn't room to go into these in detail here but the next issue of "Tips" will discuss them more fully.

Meanwhile if you have a specific problem, call on U.S.I.'s Technical Service Engineers. They will be glad to work with you toward finding a solution.

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SPE JOURNAL

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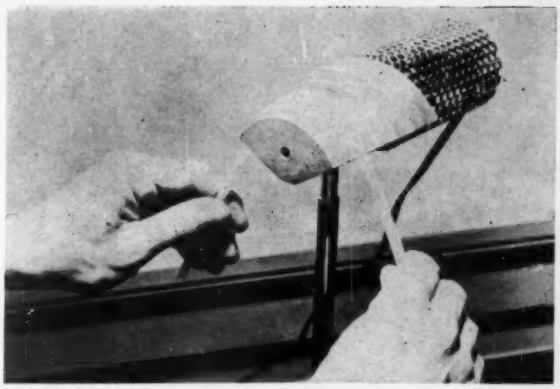

Heated fixture constructed to correct shape simplifies bending nylon tubing to desired permanent radius. Part is then chilled by dipping into water. *(Photo courtesy of Polymer Corp. of Pennsylvania, Reading, Pa.)*

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From The Editor's Notebook

By JESSE H. DAY

● At the top of this page is a ticket to an education in polyethylene. Actually it is the preprint book of the recent Cleveland Retec. One of the biggest values is the clear distinctions between low density, medium density and high density polyethylenes. You will find each type well defined, and the physical properties of each, and better yet, a run down on how to choose which polyethylene for a specific use. If you mold polyethylene, this book should be valuable to you.

● This issue of the Journal marks a proud and happy anniversary. The popular feature "SPEaking of Extrusion" has appeared for two years, and with this issue begins its third year.

● We spent last week end doing a calculation on SPE membership of the same kind that chemists do for molecules—and in the same way. Problem; find the center of gravity—in our case center of SPE membership population. Result, about 8 miles west and 6 miles south of Cleveland. If you are mathematically inclined and have a few spare hours, pick up your Roster Issue of the Journal and some paper and calculate away. If you do, drop us a line and let us know how—or rather, where—you made out.

● Interested in Japanese plastics? The Institute of Polymer Industry, Central Post Office Box 1176, Tokyo publishes the Plastics Industry News, which runs about 24 pages plus cover, monthly. It's printed entirely in English, and among other things prints a list of Japanese patents.

Calendar of SPE Technical Meetings

ANNUAL TECHNICAL CONFERENCE

"Progress Through Plastics Engineering"

January 28-31, 1958 — Detroit

The Hotel Sheraton-Cadillac

98 engineering and scientific papers on all phases of the plastics industry, including research and education —
Chairman: C. H. Whitlock, 21655 Coolidge Road, Oak Park, Mich.

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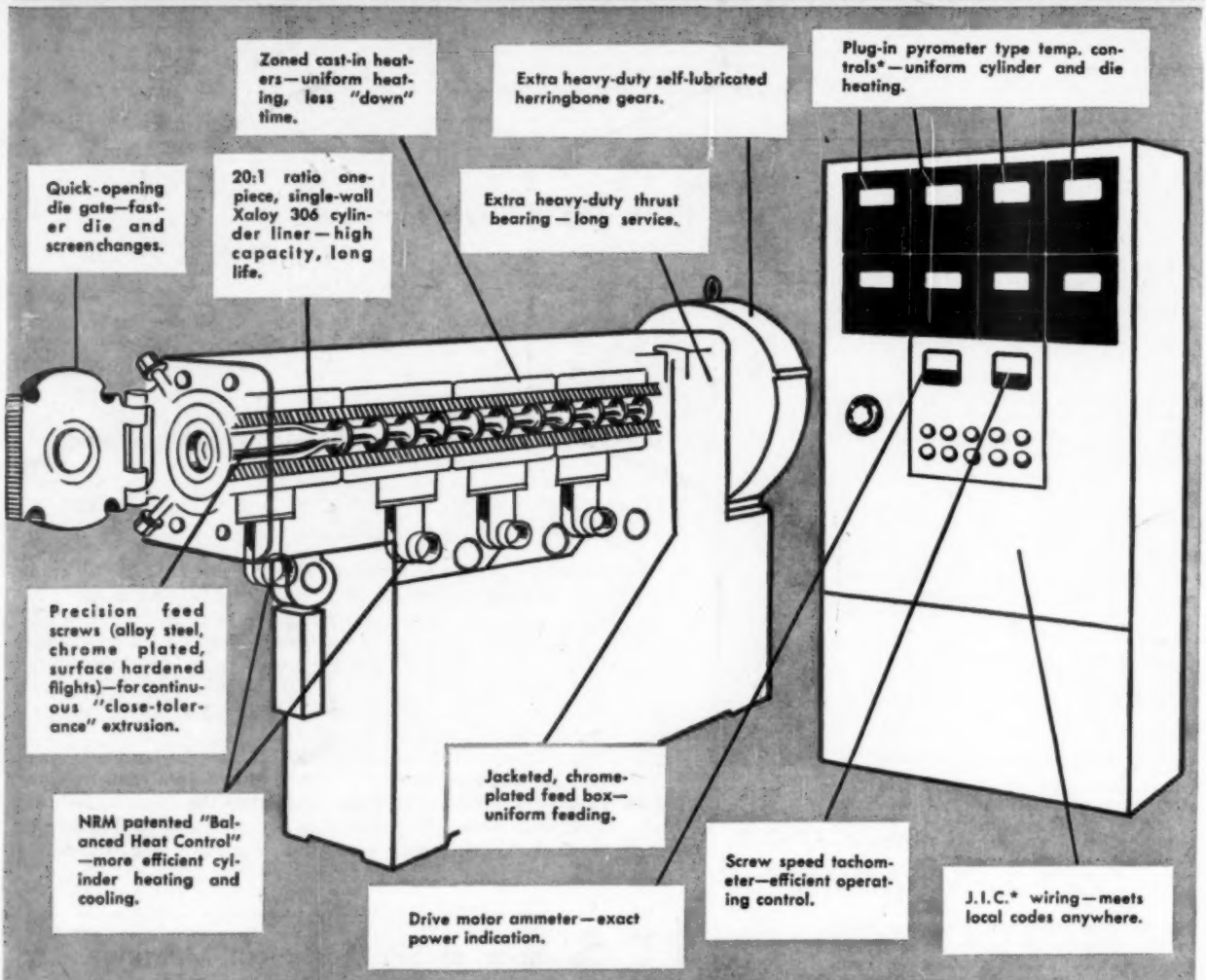
This Month's Cover:

This chess set is unusual for two reasons. First is that even the largest pieces, 4½ inches high, are transfer molded of melamine. Second is that this is the first really new design in mass-produced chess pieces in a century. It is molded for Pacific Game Co. of Culver City, California by Lee Deane Products of Los Angeles.

Tomorrow's ENGINEERING Today... with NRM Thermoplastic EXTRUDERS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Creative Engineering

Industry News

Myron Rothman

Mr. Myron Rothman has been appointed vice president in charge of production at Anchor Plastics Company. Mr. Rothman, who has been plant manager of the Long Island City concern for the past 13 years, will take on additional responsibilities brought about by the substantial expansion of the company's custom extrusion plant capacity.

Foster-Grant

Joseph C. Foster, president of Foster Grant Co., Inc., of Leominster, Mass., chemical and plastics producer, has announced the election of four new vice-presidents.

The new officers are: Jacob Chatkis, vice-president and secretary; Dr. Sidney J. Baum, vice-president in charge of polymerization; Milton W. Bernstein, vice-president in charge of sales for the Molded Products Division; and Dr. F. Drew Mayfield, vice-president in charge of the company's monomer plant in Baton Rouge, La.

Leo Gans

The appointment of Mr. Leo Gans as executive assistant at Anchor Plastics Company has been announced.

Polyethylene

"New Applications For Polyethylene" is the feature article in the current issue of American Agile Corporation's external house organ, Plastic Weldor and Fabricator.

Copies may be obtained, without cost, from the American Agile Corporation, P.O. Box 168, Bedford, Ohio.

Chemical Materials

A sixteen-page brochure lists and describes over 625 chemical compounds and products introduced by 136 chemical manufacturers during 1956. Of these products, 272 are completely new products never before offered by any manufacturer. The others were previously available, but from other manufacturers. Therefore alternate sources of supply are indicated. Names and addresses of all manufacturers are included.

"Chemical Materials—1956" is available at $1 a copy from Chemical Processing Magazine, 111 E. Delaware Place, Chicago 11, Illinois.

Dust Control

A new eight-page bulletin has been issued by the Pangborn Corporation, Hagerstown, Md., manufacturers of Rotoblast and dust control equipment, which describes Rotoblast deflashing equipment available for efficient cleaning and finishing of all types of plastic parts.

Copies of Bulletin No. 228 are available from: Pangborn Corporation, Hagerstown, Maryland.

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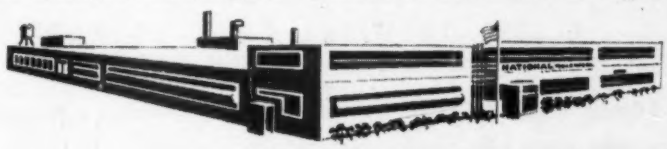

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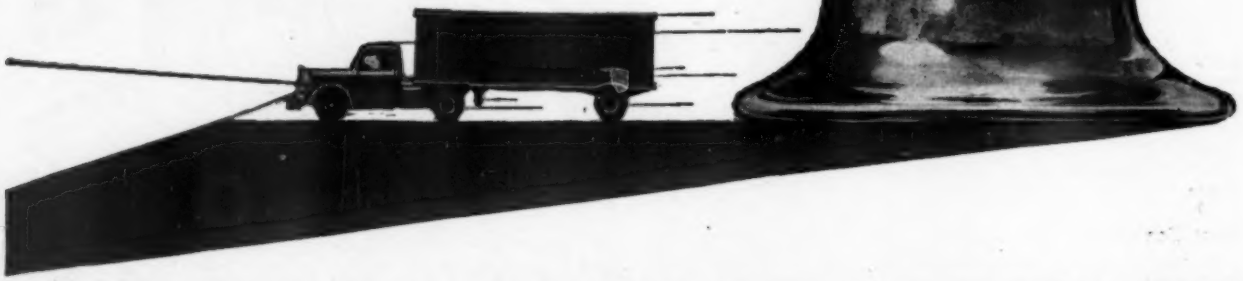

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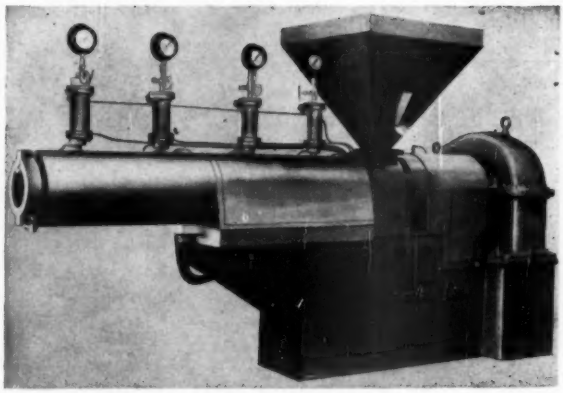

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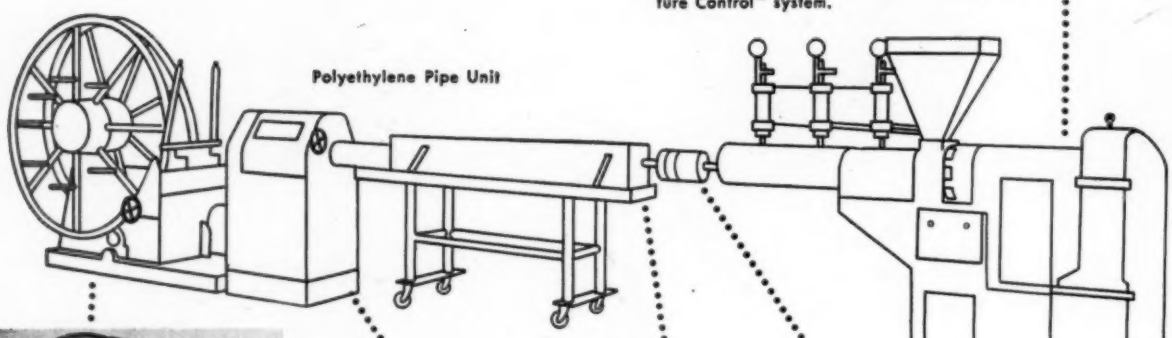
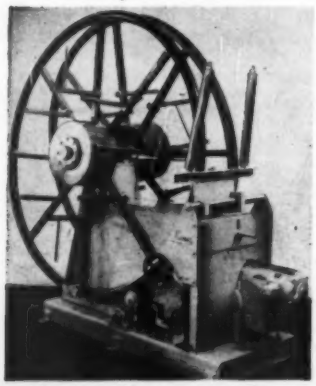


Polyethylene Pipe Unit



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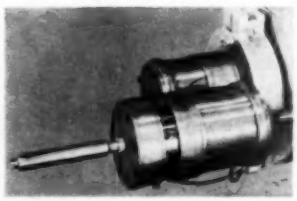

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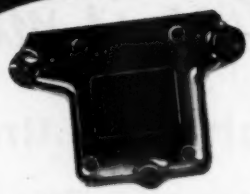

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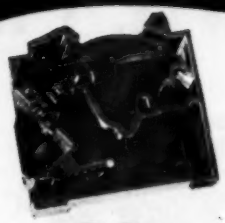
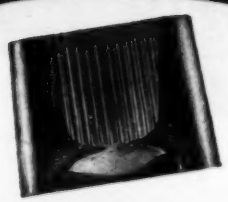


20% less time

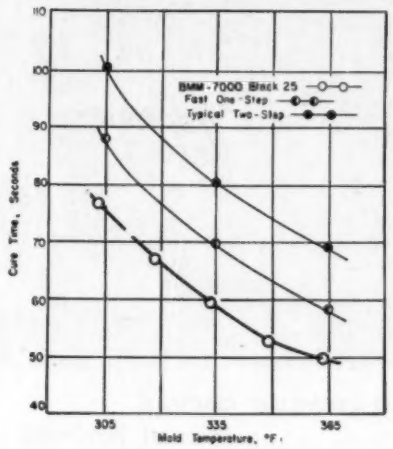
17% less time



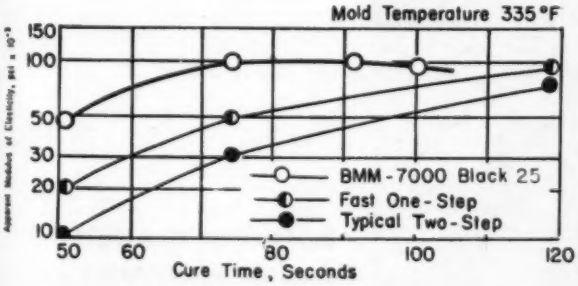
60% less time

40% less time

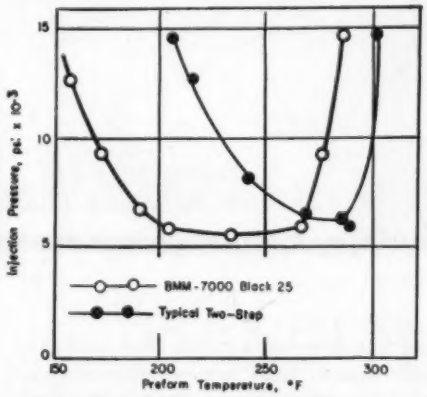
FAST CURE SPEED—BMM-7000 cured as fast at 315 deg. F. as a fast one-step material at 335 deg. F., and a two-step material at 365 deg. F., according to a test of minimum blister-free time in cold powder compression molding.



HOT RIGIDITY—BMM-7000 took 50 seconds to reach an apparent modulus of elasticity of 50,000 psi at 335 deg. F. A fast one-step phenolic took 50 per cent longer, a typical two-step material, 100 per cent longer.



MOLDING LATITUDE—As determined by plunger molding, BMM-7000 could be preheated over a wider range than general-purpose BMG-5000, and still give mold fill-out—an 87 deg. F. spread at 7500 psi, compared to 46 degrees for BMG-5000. This property makes the new material suitable for molding large pieces even with its fast cure speed.



IN ADDITION—BMM-7000 demonstrates good mold release, freedom from mold staining, low specific gravity, and low shrinkage.

TYPICAL TEST VALUES OF BAKELITE BRAND GENERAL-PURPOSE PHENOLIC COMPOUND BMM-7000

BMM-7000 BLACK 25 TYPICAL TEST VALUES

VALUES RELATING TO FABRICATION

Granulation (D392-38)	12 mesh*
Bulk Factor (D392-38)	2.3
Tableting Qualities	Easily preformed on standard equipment.
Pourability (D392-38), sec.	19
Plasticity Grades Available	6, 9, 12
Molding Shrinkage (D955-51), in./in.	0.004

*All grades supplied in special low fines granulation.

VALUES FROM ELECTRICAL TESTS

Dielectric Strength (D149-55T)			
Short time, volts/mil	330		
Volume Resistivity (D257-54T)			
ohm-cm	6×10^{12}		
	60C	1 KC	1 MC
Dielectric Constant (D150-54T)	6.1	5.7	4.6
Dissipation Factor (D150-54T)	0.08	0.04	0.03

VALUES FROM MISCELLANEOUS TESTS

Molded Specific Gravity (D792-38)	1.36
Heat Distortion Temperature (D648-45T) deg. F.	330
Water Absorption (D570-54T) % wt. gain	0.5

VALUES FROM MECHANICAL TESTS

Izod Impact Strength (D256-54T) (Ft. lb./in. of notch)	0.29
Compressive Strength (D695-54), psi	35,000
Tensile Strength (D651-48) (¼"), psi	6,900
Flexural Properties (D790-49T)	
Flexural Strength, psi	9,000
Modulus of Elasticity in Flexure, psi	9.5×10^5

WRITE FOR MORE FACTS... TEST IT YOURSELF!

Molders who have already tried this new general-purpose phenolic have found it an impressive time-saver. Find out for yourself,—try it in your own operations. Write for complete data and samples to Dept. AU-171

BAKELITE
BRAND
PLASTICS

UNION CARBIDE

Bakelite Company, Division of Union Carbide Corporation
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In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ont.

Butyrate conduit is joined easily

Using slip-sleeve couplings and solvent cement, two Kingsport Utilities crewmen laid 247 feet of a "white way" line in only 20 minutes—a fraction of the time it would take with conventional materials.

Butyrate conduit curves without fittings

To follow ditch contours in this installation, Brookville Telephone Company, Brookville, Indiana, used semi-rigid conduit of Tenite Butyrate—and eliminated the need for many right angle fittings.

Conduit of Tenite Butyrate plastic offers users many advantages

Conduit of Tenite Butyrate plastic is finding ever-growing acceptance among progressive utilities for use in carrying electric power or telephone cables.

Utilities are discovering that Butyrate is an ideal material for cable conduit. It is tough, durable, corrosion resistant and non-inductive. It can withstand all normal abuse before, during, and after installation. What's more, conduit of Tenite Butyrate is available in 20-foot lengths to reduce the number of joints in the line. The lightweight lengths can be cut with ease and joined in seconds with slip-sleeve couplings and solvent cement. Users report substantial savings in installation and maintenance.

Tenite Butyrate is a versatile plastic used in many different forms in many different fields. For more information on properties and uses, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

Butyrate conduit resists corrosion

Tenite Butyrate was chosen by Community Public Service Company as the duct material to successfully combat the strong alkali soils found in the Pecos, Texas area.

TENITE
BUTYRATE
an Eastman plastic

Information regarding Tenite also can be obtained from local representatives listed under "Plastics—Tenite" in the classified telephone directories of the following cities: Atlanta, Chicago, Cleveland, Dayton, Detroit, Houston, Kansas City, Leominster (Mass.), Los Angeles, New York City, Portland (Ore.), Rochester (N. Y.), St. Louis, San Francisco, Seattle and Toronto—elsewhere throughout the world, from Eastman Kodak Company affiliates and distributors.

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Advanced engineering and outstanding manufacturing quality are combined in Wheelco instruments, whether the job calls for recording, controlling, or indicating. The complete Wheelco line of instruments, together with unmatched experience in every type of plastic industry installation, is your assurance of satisfaction.

Here's how Wheelco will go to work for you:

Field Engineering— A complete analysis of your needs by a broadly experienced Wheelco field engineer gets your job started right. Where required by special installation problems, additional backing is provided by specialists at Wheelco's home office.

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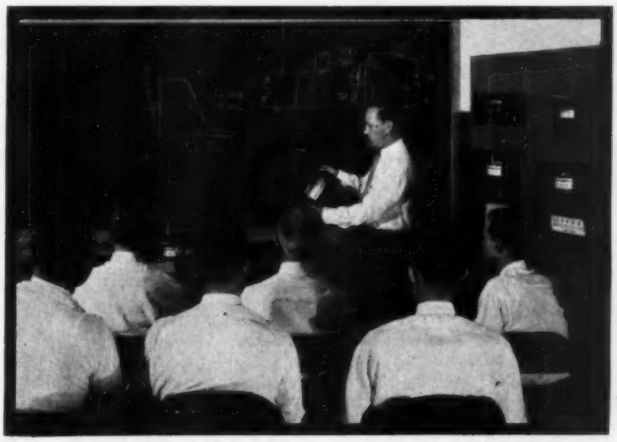

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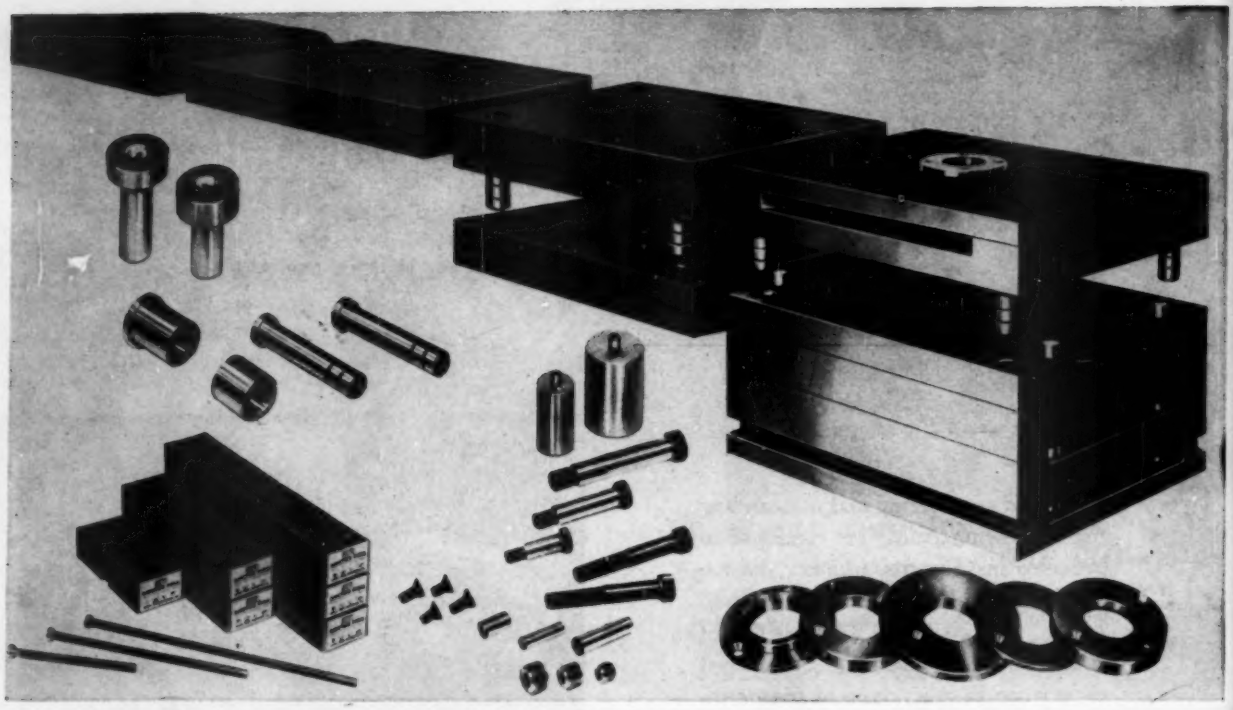

PROGRESS THROUGH STANDARDS

. . . and how DME "helped"

The history of economy in modern business has been directly related to the history of Standardization. One of the major elements affecting the economic production of finished plastic parts is the high initial cost of the mold. A progressive step in reducing mold cost, without sacrificing the high quality required, has been successfully achieved through Standardization.

When D-M-E originated Standard Mold Bases and their component parts in 1942, it provided the answer to the rapidly growing demand for high quality molds that would maintain and promote the economic advantages of plastic parts.

Through large volume purchases of quality steel in standard sizes and specialized production facilities, D-M-E was able to produce and supply high quality Standard Mold Bases to mold makers and molders at such great savings in cost and time that the benefits of Standardization were quickly realized by the Industry.

Today D-M-E produces twenty-eight different sizes of Standard Mold Bases, from 9" x 8" to 23¾" x 35½", in either D-M-E No. 1 or No. 2 Steel, with a wide range of cavity plate thicknesses to satisfy the diversified demands required. In addition, over 2,000 finished component parts of the same high quality are available to provide additional savings in service as well as in the product.

Properly engineered Standardization puts the accent on Economy. When you "Specify D-M-E . . ." you get Quality, Service AND Economy!

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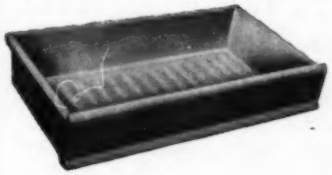
CRUCIBLE CSM 2 mold in press at Pro-phy-lac-tic Brush Co., Florence, Mass. The mold, built by Eagle Tool & Machine Co., Hillside, New Jersey, produces vegetable pans for Hotpoint refrigerators.



why **CRUCIBLE CSM 2**

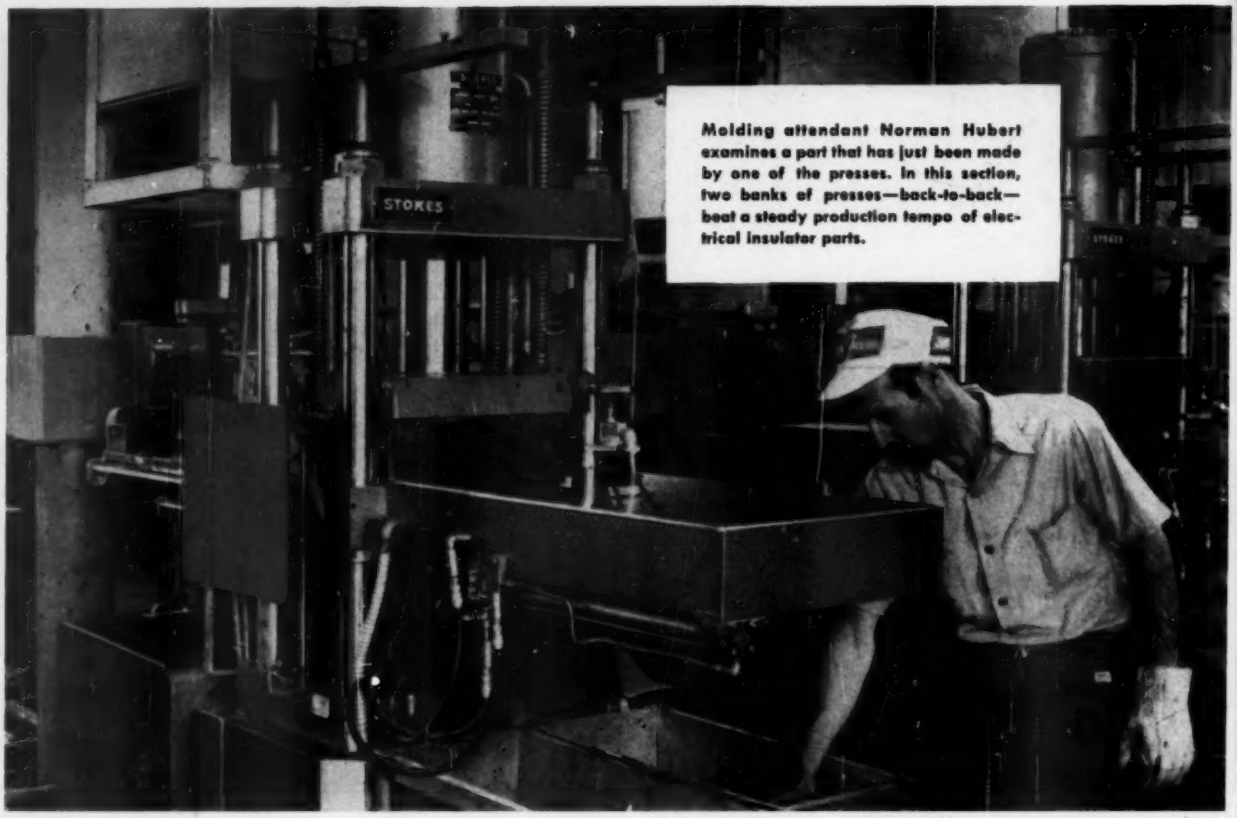
is chosen for so many big molds . . .

One reason is that CRUCIBLE CSM 2 is always uniform in structure and composition. It's got to be. For the quality of every *heat* is controlled by Quantometer analysis. . .and every *piece*, regardless of size, is ultrasonically inspected. This means superior machining and polishing characteristics.

Another reason is that CRUCIBLE CSM 2 is immediately available from *warehouse* stock in 205 sizes, big and small. The job isn't held up for steel when you order CSM 2, the mold steel you can *trust* and get *when* you want it. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America



Molding attendant Norman Hubert examines a part that has just been made by one of the presses. In this section, two banks of presses—back-to-back—beat a steady production tempo of electrical insulator parts.

Bryant Electric's Plastics Department buys additional Stokes Model 741's

The Bryant Electric Company, Plastics Department, a subsidiary of Westinghouse Electric Corp., is thoroughly convinced of the excellence of Stokes automatic molding equipment. Twenty Model 741 50-ton presses have been in constant use, with another six just installed. Molded insulating parts for electrical appliances, lighting fixtures, switch gear, wiring devices, and the like, are being produced at high rates of speed—with dependable precision.

The Plastics Department of Bryant selected Stokes equipment for its high standards of workmanship and excellence of service. Fully automatic production of these parts requires minimum monitoring . . . results in lower manufacturing costs and enables them to meet competition more favorably.

Built into these new 741's are refinements that Stokes has developed during 25 years of leadership in automatic molding:

Positive top knock-out—an exclusive Stokes feature.

No mold damage—from parts falling back in the die.

Simplified feed set-up—changeovers take only 5 minutes.

Fastest press cycles—8 seconds dry cycle time is 40% faster than any comparable machine.

Space-saving design—cuts costly floor area requirements.

Tops in versatility—handles greatest variety of parts and materials.

Stock die sets—are designed to 741 specifications.

Capacities of 50, 75, 125 and 200 tons are available. Write for our latest bulletin, and for a consultation on your molding problem.

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F. J. STOKES CORPORATION
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STOKES

CYANAMID

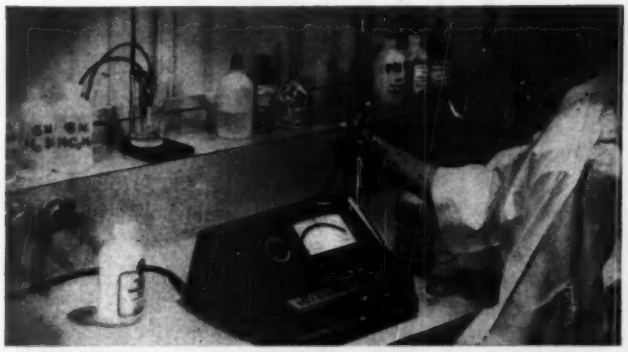
PLASTICS NEWSFRONT

EYE-LURING COLOR CAPS BEST-SELLING PACKAGES

To compete for attention on crowded toiletry counters and shelves today, many best-selling products add a cap of colorful BEETLE® Urea Molding Compound. The beauty of color—any color—is permanently molded in. Closures of BEETLE Plastic are practical, too: they resist alcohol, acetone and other solvents, resist staining, and don't have an electrostatic affinity for dust, so stay clean longer on shelves.

NEW PIPE JACKET STOPS UNDERGROUND CORROSION

Strong jackets of spirally wrapped glass cloth and LAMINAC® Polyester Resin combat corrosion in new prefabricated insulated pipe conduit for underground steam and hot-water systems. Developed by Temploc, Inc., Baldwin Park, Calif., the protective two-ply shell is much lighter, less costly and more corrosion resistant than conventional steel or tar-protected conduit. Insulation is sealed and vapor-proofed at the ends by bonding the cloth-resin shell directly to the bare pipe. Field joints of insulation, cloth and resin are easily applied at the site.



IMPROVED HOUSING FOR NEW pH METERS

To make the housings for Pocket model and ZER O MATIC* bench model pH meters (shown) unusually strong, impervious to chemicals and resistant to scratching and chipping, Beckman Instruments, Inc., molds them of CYMEL® 1077 Melamine Molding Compound. This tough, break-resistant plastic protects the delicate mechanism and also provides the attraction of color without the added production steps required in finishing metal. Color is part of the housing itself; there is no coating to wear or chip off . . . no metal to corrode. *Trademark Beckman Instruments, Inc.

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MATERIALS FOR TOMORROW

What they're **both** saying about new Lustrex* Hi-Test 88B

Both extruders and formers have found Lustrex Hi-Test 88B extrusion-grade is an extremely versatile high impact styrene compound. It answers the extruder's need for a material that can produce sheet particularly qualified for vacuum forming high-grade lighting fixtures, packaging, toys or industrial applications requiring high-impact strength. For complete technical information, write Monsanto Chemical Company, Plastics Division, Room 1880, Springfield 2, Mass.

Monsanto

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"Fast Extrusion . . .
Excellent Gloss . . .
Smooth Surface Finish!"

vacuum formers:

"Excellent Flow . . .
Uniform Thickness . . .
Even Residual Strength!"

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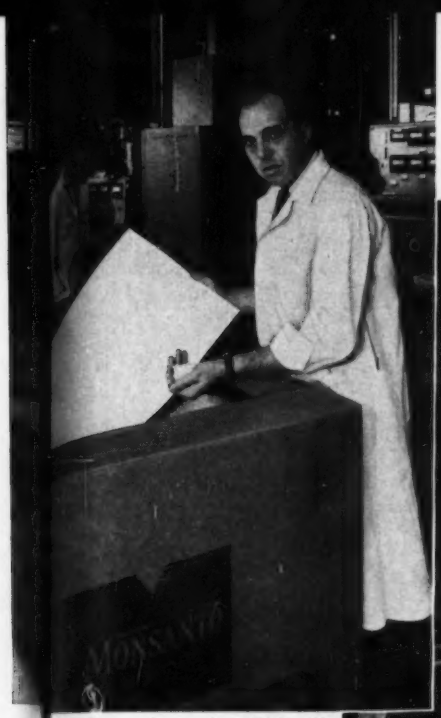
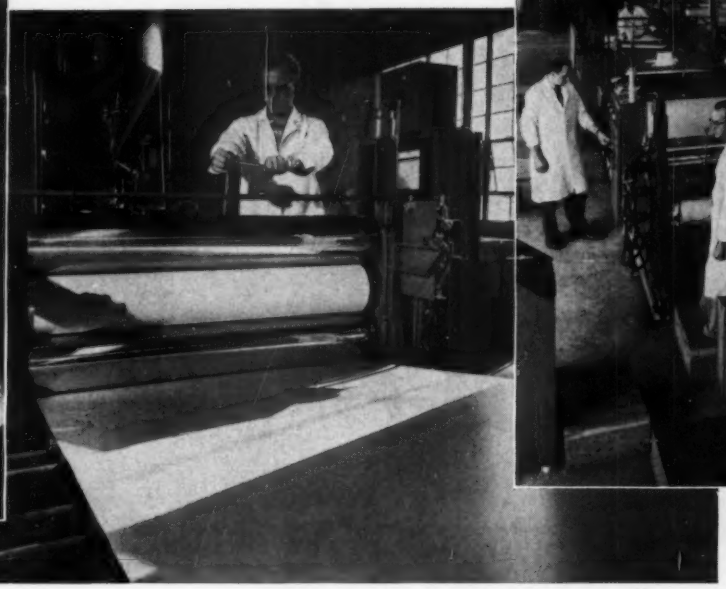


"Uniform dry colorability."
"Excellent gloss
in all colors . . ."
"'whiter' whites . . ."

"We like the fast rate at which Lustrex Hi-Test 88B can extrude sheet on standard machines."



"The sheet has a smooth finish . . ."
"free from streaks, fish-eyes . . ."
"more re-usable scrap . . ."

"Complex shapes with no loss of strength . . ."
"Deep draw molding with no sacrifice of wall thickness or toughness . . ." "Sharp detail . . ."

xcellent flow. Sheet fills
t mold very uniformly."
inimum blow-outs in
ep drawing."

"Formed product has uniform thickness and residual strength."
"Good dimensional stability facilitates assembly operations."

It's Getting Late . . .

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14th Annual Technical Conference

"Progress Through Plastics Engineering"

January 28, 29, 30, 31, 1958

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Members and non-members are welcome to this 14th Annual Conference. Over one hundred papers will be presented on the latest developments, methods, materials, and techniques in plastics engineering.

Make Reservations Today — Don't Delay!

Glass Reinforcement for Structural Plastics

R. G. Adams and Ralph Sonneborn
Owens Corning Fiberglas Corp.
Ashton, Rhode Island

. . . choice of glass reinforcement should depend on sound knowledge of the kinds available and the special virtues of each, to get the needed properties in the end product . . .

Reinforcement is of prime importance in structural plastics. Glass as a reinforcement for plastics is used in a wide variety of forms. Translucent sheets of fiberglas reinforced plastics are well known in many areas of the building industry but they use only one of the many forms of glass reinforcement including mats, rovings, fabrics and yarns. When we realize the great design latitude possible in strength, rigidity, shape, size, directional characteristics, cost and production methods with these materials, it becomes apparent that we have the means at hand of producing many new and different forms of structural building components.

The basic fibers are, in general, manufactured from a lime-alumina borosilicate glass that is relatively soda free. It is commonly referred to as "E" glass. The individual fibers, or filaments, are made in several different diameters from .00020 inch to .00100 inch.

Difference Between Fibrous and Bulk Glass

Fibers have many of the characteristics of bulk glass, but some properties are severely modified. Mechanical strengths are increased and the chemical resistance is reduced.

The tensile strength of glass fibers is about 400,000 psi; this value is independent of the filament diameter. The modulus of elasticity (E_t) is close to that of bulk glass: 10,500,000 psi. The modulus of resilience (the energy absorption characteristic) is increased a thousand fold by the fibrous form.

The question has often arisen as to whether glass is truly a liquid or a solid. Although technically a supercooled liquid, for most practical purposes it can be considered a solid, since the viscosity at room temperature is extraordinarily high.

How the Basic Fiber is Manufactured

There are three basically different processes for manufacturing glass fibers: steam or air blowing, flame blowing and mechanical pulling.

Most fibers used for the reinforcement of plastics are made by mechanical pulling. The two blown fiber methods are used primarily for the manufacture of air filters, insulating materials and staple yarns.

All three processes depend upon a small electric furnace with a number of metering orifices in the bottom. Molten glass flows through these orifices and fibers are attenuated from this molten stream.

The bottom of the furnace which contains the orifices is known as a bushing. The design of bushings is very critical. Because of the high temperatures involved, they often contain substantial amounts of the "noble metals".

Two methods are used to feed raw glass into the bushings; direct batch feed and marble feed. Direct batch feed consists of mixing the glass ingredients and melting them in a large gas-fired furnace. The molten glass then flows to the fore hearth where it is brought up to the proper temperature and is metered into the bushing. Where a marble feed is used, the molten glass is rolled into small marbles which can be shipped to the fiber forming plant. These marbles are fed into the bushing on small tracks.

The blowing processes consist of jets of air, steam or hot gas being directed at the molten steam. Short staple fibers are attenuated and become cool. Where extremely fine filaments are desired, a relatively thick "primary fiber" is mechanically pulled from the bushing and is in turn remelted and blown by a jet of extremely hot gas.

The mechanical pulling method produces a continuous fiber by mechanically drawing a filament from the stream of molten glass. During the early stages of cooling, the

stream is attenuated into filaments by being pulled at very high speeds, normally in the range of 5,000 to 10,000 feet per minute. Depending upon the pulling speed, the orifice size, the molten glass temperature and other variables, the filaments have a diameter from .00020 to .00075 inch.

For efficient production a number of filaments are formed simultaneously, one from each orifice in the bushing. These filaments are collected into a bundle known as a "strand" at a gathering device where a surface treating material called "size" is applied. Below this is a winding apparatus which winds the strand into a forming package.

This basic forming package, often known as a "cake" consists of one strand (usually made up of 204 filaments) wound onto a flexible tube. The forming package is rather delicate and hence is merely an intermediate product from which the shippable forms of fibrous glass are produced.

Importance of the Fiber Surface

The key to an understanding of the properties and processing methods regarding fibrous glass is held in an understanding of the fiber surface. Glass is an inert material, but because of the extremely great ratio of surface area to volume (one pound of roving has about 880 sq. ft. of surface), a proportionally small amount of chemical attack is magnified into a significant quantity. Therefore, a really clean surface is almost hypothetical.

A virgin fiber, at the moment of formation, is uncontaminated. However, within a few seconds, it has been superficially attacked by moisture from the air. When the glass is under load, this phenomenon can cause what appears to be fatigue. However, fibers of glass show neither creep nor hysteresis at room temperature.

Glass does not bond well with plastic materials. The surface must be prepared for acceptance of a resin in much the same manner that some metals must be primed before being painted.

Glass Surface Treatments

The glass filaments are very susceptible to abrasion from one another. Consequently, immediately after forming, a lubricant must be applied. Also, it is necessary to bond the filaments together in the strand. Otherwise they cannot be handled in subsequent operations without becoming very fuzzy. Resins do not adhere to the glass, so an intermediate material known as a coupling agent must be applied to provide adhesion. Thus the surface treatment must serve three functions: as a lubricant, as an adhesive or bonding agent between filaments, as a coupling agent (a primer).

In the manufacture of certain types of reinforcements (yarns and woven fabrics), the glass is subjected to a great amount of abrasion. The demands on the lubricant are great. It is unfortunate that the most effective lubricants act as a deterrent to the resin-to-glass bond. In the manufacture of these materials, therefore, it is necessary to sacrifice the coupling action of the size in order to get sufficient lubrication action. As a result, molding resins will not bond well to the yarns and fabrics. So, it is necessary to burn off (heat clean) the size after the weaving is accomplished and then apply a coupling agent. This coupling agent is known as a "finish". Two general types of finishes are used: silanes and "chromes"; the choice is dictated by the strengths required and the costs permitted.

In the manufacturing of some types of reinforcements, (mats, rovings and chopped strands), the fibers are not subjected to rigorous abrasion. In their processing, it is possible to apply a size that fulfills all the three requirements. These sizes give good coupling action so that no heat cleaning and finishing operation is required. Since this extra step in the manufacture is eliminated, these reinforcements are generally lower in cost than those that are finished.

These plastic-compatible sizes contain the same type of silane or chrome materials as are used in the finishes. The amount and type of bonding agent and lubricant can be varied to give a range of "hardness" and "fuzziness". In general, the type of coupling agent is dictated by the strength requirements of the molded part and the bonding agent is decided by the molding techniques to be used.

Forms of Reinforcement Available

Today's common building materials find use in many seemingly unrelated applications because they are versatile. The same versatility is available in structural plastics due to the many forms of Fiberglas reinforcement available.

Reinforcing Mats

These non-woven mattings are made of either chopped strands or swirled continuous strands that are laid down in a random pattern. The strands are held together by means of adhesive resinous binders or are mechanically bound by "needling". The mats and their binders are tailored to the various manufacturing processes.

For continuous laminating, a process widely used for the manufacture of translucent sheets, mats are available bonded with a binder which is soluble in the polyester molding resin. The rate of solubility is controlled so that the mat can be continuously impregnated before it loses its bond. The soluble binder permits the sheets to have a high degree of translucency.

This same type of binder is used in mats of high strand integrity which are especially suited to hand layup work due to their porous nature which permits fast wet-through of resin.

Mats made with binders which do not dissolve in the molding resin are designed for use in press molding with heated matched molds. Where production volume is sufficient, the attendant savings permit an economic breakthrough of reinforced plastics into fields which have been dominated in the past by metal stampings, die castings and molded plywood.

Low solubility mats are also used in the press molding of flat sheets for use in structural sandwich panels and electrical applications.

Where parts of more intricate or deeper contour call for more formability in press molding, mechanical swirl mats are used. They can often be used in parts which formerly would have required preformed reinforcement.

Mats are lower in cost than woven materials, but are slightly more expensive than bulk chopped strands or rovings. The cost will vary according to the weight and bonding method employed.

Rovings

Rovings are made from "cake" packages. A number of continuous strands, commonly 60, are gathered together and wound on a tube to form a cylindrical package.

Rovings are used in making preformed reinforce-

ment. The rovings are chopped into predetermined lengths which are blown or sucked onto a perforated screen the shape of the part to be molded. This combination of material and process makes possible the press molding of very large or complex structural shapes on a volume basis.

Rovings are also used where unidirectional strength is required. When used in parallel strand laminates, rods or bars, roving provides one of the highest strength structural plastics available. Simple cross section shape can be made continuously by a process which combines resin impregnation of roving with pulled extrusion of the material.

Rovings are also used by fabricators who wish to make their own flat mats. Spun roving, a newly developed roving that is a lower cost form, consists of one single continuous strand that is looped and wound into a roving-like form. It has found wide acceptance in the form of chopped strands in molding compounds and premixes. By using a one inch cut, spun roving can be preformed successfully.

Chopped Strands

Strands can be cut into short lengths for use in the preform process and in the manufacture of molding compounds. They are made by passing continuous strands from the forming package through a cutter which chops them into pre-determined lengths, usually from one-half inch to two inches. They are available as bulk fibers, usually packed in bags.

As mentioned before, chopped strands can also be made from spun roving. This is one of the lowest cost forms of glass reinforcement. Fiberglas reinforced molding compounds or premixes, like other molding compounds, can be molded into complex shapes on conventional equipment at high rates of speed.

Milled Fibers

Continuous strands from basic forming packages can be hammermilled into small modules of filamented glass. These fibers are available in nominal lengths from 1/32 inch to 1/4 inch. They are used largely for anti-crazing filler reinforcement in casting resins and in resin adhesives, (bonding joints) where they give greater body and dimensional stability to the adhesive.

Yarns

These are made on standard textile equipment from the basic forming package. Although primarily an intermediate material in the manufacture of tapes and fabrics, they have been used for rod stock. The lower cost rovings have largely supplanted yarns as a direct reinforcement for plastics. When yarns are used, they must be heat cleaned and finished in order to get proper resin-to-glass adhesion. Yarns are used, however, in the filament winding process to manufacture very high strength spherical containers, cylinders and pipes.

A form of yarn is the warp beam, where many parallel yarns are wrapped on a mandrel. This form is not in widespread use, but is a more convenient form for handling a large number of yarns for unidirectional reinforcement.

Surfacing and Overlay Mats

Where the smoothest possible surface is desired on a molding, thin mats of staple monofilaments can be placed over the reinforcement. These mats offer prac-

(Please turn to page 79)

Comparison of Reinforcements

Type	General Description	Normal Glass Content	Directionality	General Use	Typical Application	Relative Materials Cost
Chopped Strands	Bulk cut Strands	35-45%	Multi-directional	Molding Cmpd.	Electrical components	Low
Rovings	Rope-like bundle of continuous strands	50-70%	As desired	Preforming; Unidirectional reinforcement	Machine Housings; rod stock	Low
Reinforcing Mats	Chopped or continuous strands in non-woven random matting	20-45%	Multi-directional	Parts with simple contours	Translucent sheet; truck body panels	Medium
Milled Fibers	Bulk, small filamentized modules	2-10%	Multi-directional	Adhesives & castings	Secondary bonding	Low
Yarns	Twisted yarns with after-finish	60-80%	Uni-directional	Unidirectional reinforcement	Fishing rods	High
Surfacing & Overlay Mats	Non-reinforcing monofilaments in random matting	5-15%	Multi-directional	To improve surface smoothness	Automobile bodies	High
Woven Fabrics	Woven cloths with after-finish available in many styles	45-65%	Uni-dir. or bi-dir.	High performance parts	Radomes	High
Woven Rovings	Coarse, heavy fabrics	50-70%	Uni-dir. or bi-dir.	High performance parts	Large containers	Medium

Molding, Quality Control and Some Aging Characteristics of Nylon

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THEORETICALLY, the degree of crystallinity in molded nylon is somewhat dependent upon the rate of cooling of the nylon from the molten state to the solid state. Highly crystallized nylon is stiff while the more amorphous nylon exhibits a toughness characterized by high tensile strength and by high elongation. Therefore, controlling crystallinity during molding is of great importance to the molder and to the consumer.

The molder is very concerned with the occasional unexplained brittle piece that shows up in an otherwise good production run. Molders have quoted figures of from 3 to 15% occurrence of such brittle specimens. Their problem is to eliminate or control brittleness and to check the product by some quality control test which will discriminate between tough and brittle pieces. The consumer in turn is concerned with the hygroscopic nature of nylon and the effect this might have on its performance as a serviceable item. The Navy is concerned with the aging quality of nylon at extreme temperature and humidity conditions.

It was felt that a study was needed to establish the molding condition limits for tough nylon, to develop a quality control method and to measure some of the basic material properties.

In an initial approach to studying the toughness characteristics of nylon, fifty standard ASTM tensile bars were molded of duPont's nylon resin Zytel 101 NC-10. The samples were molded in a relatively hot mold (200°F) with the other molding variables controlled to give a specimen of good visual quality. Except for two specimens which were brittle and showed no perceptible elongation before failure, uniform tensile properties were experienced. Two typical specimens from this test are shown in Figure 1. Examination of the brittle specimen showed the break originating at an imperfection in the piece. This imperfection seemed to be an occlusion or could possibly be an area where a change in crystal size occurred.

Because of these tensile results, the program was expanded to study the brittleness phenomenon more thoroughly. For ease of testing and because of an end item development, a ring type specimen was selected as the test configuration. This ring specimen is shown in Figure 2.

Molding variables vs. the tensile properties of the ring were investigated. The rings were molded in a four-cavity mold in groups of 40 specimens using a one-ounce Van Dorn injection machine. The nylon was dried in an air circulating oven at 170°F for a minimum of 3 hours. Three cylinder temperatures and three mold temperatures were studied. Cylinder temperatures, reading rear to front, were 470°F-490°F., 530°-550°F., and 570°-570°F.

Figure 1. Typical Tensile Breaks.

These temperatures were not necessarily the temperature of the molded nylon. Mold temperatures investigated were 60° F., 140° F., and 200° F., and were controlled by a Sterlco mold temperature regulator.

The tensile properties of the molded rings were checked on an Instron test machine at strain rates of 20"/min. and 1"/min. The jaws of the machine were replaced with the fixture shown in Figure 3. Specimens were placed on the fixture with the gate at the top to eliminate the weld line effect. All specimens were tested within two hours after molding to eliminate the moisture effect.

The tensile results showed insignificant variations in ultimate strength properties. Elongation variations were, however, significant, mostly due to the brittle breaks that occurred. A typical brittle break is shown in Figure 4 and a typical elongated break is shown in Figure 5. The brittle break can be described as a failure that occurs prior to any perceptible "necking" or reduction in cross-sectional area or by failure on the propor-

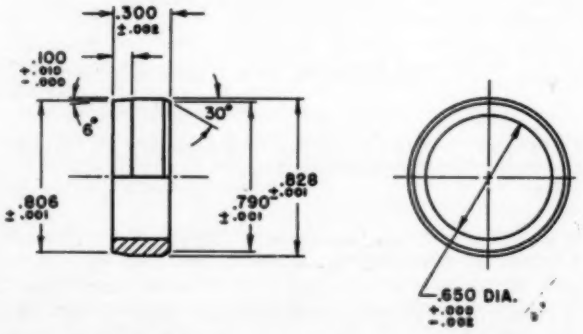
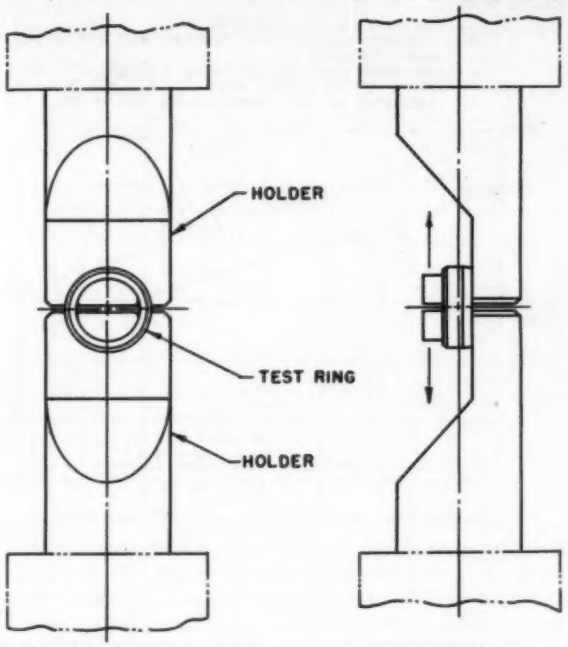


Figure 2. The test ring.

This paper was presented at the First Technical Conference of the Baltimore-Washington Section of SPE.

Figure 3. The Ring test fixture.



tional or straight portion of the stress-strain curve. It occurs with sufficient vigor to make shielding a necessary precaution. Figure 6 pictures the results of the test. The low-mold-temperature runs showed the least susceptibility to brittle failures regardless of cylinder temperature settings.

A recent paper (1) stated that the fabricator could not alter the fine structure of nylon moldings by varying the molding cycle and specifically by changing the mold temperature from 122°F to 212°F. On the other hand, this ring test shows that brittleness was affected somewhat by mold temperature, but no crystallinity studies of the ring specimens were made to determine whether or not the brittleness effect was due to crystallinity differences. As can be seen, brittle specimens throughout the test ranged from 8% to 61% when tested at 20"/min and from ½% to 10% when tested at 1"/min. These results indicate that the occurrence of brittle failures can be limited by controlling the process variables. Because the brittle break was not eliminated by varying the process variables, further investigation of the phenomenon was indicated.

Because of the variance experienced by molding temperature conditions, it was assumed that some of the brittleness could be attributed to non-uniformity of the nylon as received from the material supplier or to temperature variations in the molten nylon while in the cylinder. The relative viscosity, moisture content, and presence of foreign matter in the nylon molding material were checked. Molding variables including temperatures, pressures, and molding times were also studied.

Of all of the possible material and process variables outlined above, the cycle timing had the greatest effect on brittleness. Variations in cycle times using set conditions on all temperatures and pressures gave a brittle range from less than 1% to 16% when tested at 1"/min. The variations in cycle times in practice (and in this study) occur only in mold-open time. Usually this is dependent on the operator, his speed in removing the piece and in getting ready for his next shot. A lapse of time here allows the material to become overheated

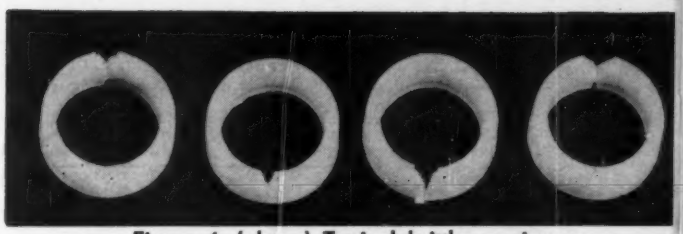


Figure 4. (above) Typical brittle specimens.

Figure 5. (below) Typical elongated specimens.

in the cylinder. If this time is not controlled, variations in the properties of the moldings occur and can be detected by the ring test. Closely controlled mold-open times have reduced brittle failures from as much as 16% to less than 1% of 200 rings tested. In many molding runs (about 50% of the total made) no brittle failures, in 200 specimen lots, were experienced.

As a trial, the ring-pull test was employed as a quality control measure in a production run. The production called for 10,000 rings, of the dimensions of the test ring, to be molded onto a metal insert. One test ring was molded for every 25 pieces. The mold had four cavities and the pieces and rings were labelled to designate the cavities from which they came. They were also packaged to correspond to the molding sequence.

In this production run, a lot (1250 units) was considered defective if more than 1% brittle specimens were

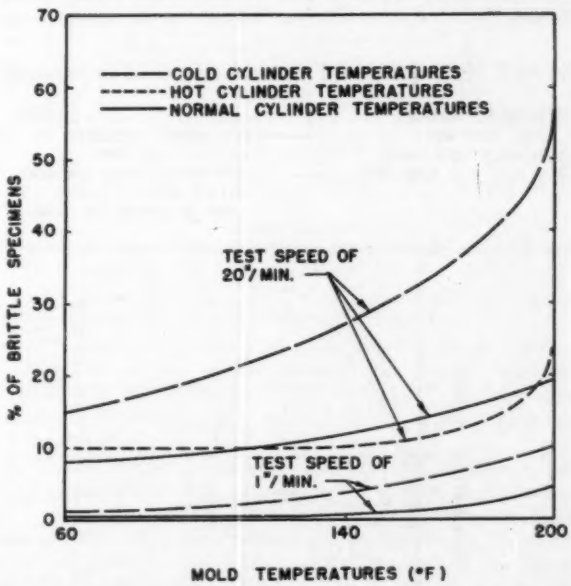
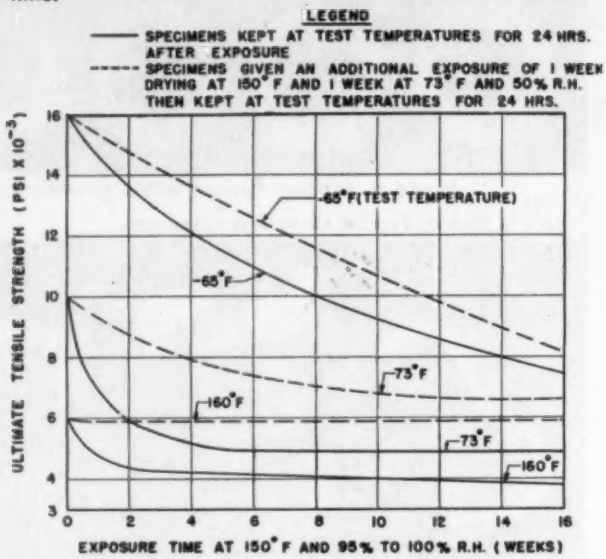


Figure 6. Percent brittle specimens plotted as a function of mold temperature.

Figure 7. Nylon (Zytel 101) tensile strength vs. exposure time.

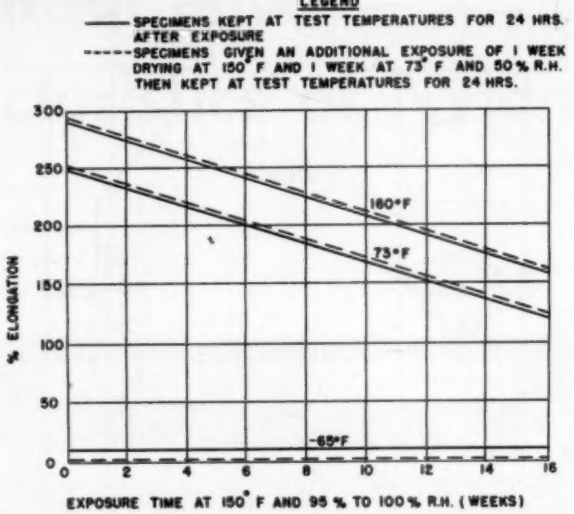

LEGEND
SPECIMENS KEPT AT TEST TEMPERATURES FOR 24 HRS. AFTER EXPOSURE
SPECIMENS GIVEN AN ADDITIONAL EXPOSURE OF 1 WEEK DRYING AT 150° F AND 1 WEEK AT 73° F AND 50% R.H. THEN KEPT AT TEST TEMPERATURES FOR 24 HRS.
ULTIMATE TENSILE STRENGTH (PSI X 10⁻³)
-65°F(TEST TEMPERATURE)
-65°F
-73°F
-160°F
-73°F
-160°F
EXPOSURE TIME AT 150° F AND 95% TO 100% R.H. (WEEKS)

present. Under the sampling plan, acceptance of a lot was based on 1 allowable failure of 75 samples per lot. This statistically might accept 8% of the bad lots and reject 10% of the good lots.

The results of the sampling plan showed that one lot was defective. One cavity during a period from midnight to 8 a. m. experienced 6 brittle specimens per 25 specimens tested. Only nine brittle specimens occurred in the total of 400 samples tested. This experience showed that a lot of 1250 units would be rejected from the one cavity. In later service tests it was further shown that failures occurred on the units from the rejected lot and not on the others.

The possible reasons for failure to meet the standards are two. First, the offending cavity was probably defective and should be reworked and, secondly, the midnight shift should have closer supervision. This need for closer supervision is emphasized by the process data which showed that the time interval between shots varied from

Figure 8. Nylon (Zytel 101) percent elongation vs. exposure time.


LEGEND
SPECIMENS KEPT AT TEST TEMPERATURES FOR 24 HRS. AFTER EXPOSURE
SPECIMENS GIVEN AN ADDITIONAL EXPOSURE OF 1 WEEK DRYING AT 150° F AND 1 WEEK AT 73° F AND 50% R.H. THEN KEPT AT TEST TEMPERATURES FOR 24 HRS.
% ELONGATION
160°F
73°F
65°F
EXPOSURE TIME AT 150° F AND 95 % TO 100 % R.H. (WEEKS)

20 to 33 seconds during the run, with the longer lapsed times occurring in the midnight shift. The midnight shift averaged 29 seconds between shots whereas the day shift averaged 23 seconds.

The importance of close control in molding has been shown in the aforementioned run and possibly a no-reject run could have been effected by holding the time between shots constant.

In gathering characteristic data on nylon, the behavior of moldings stored under adverse weather conditions was studied. Because of the hygroscopic nature of nylon and because of possible recrystallization by annealing, a hot-wet environmental effect was studied. Molded nylon samples were exposed for a period of 16 weeks to 150°F. and 95-100% RH. Test samples were removed after storage of one, two, four, ten and 16 weeks. Specimens for tensile and impact were tested as conditioned (wet) at each of the above intervals. Other specimens were dried at 150° F. for one week after each interval and were then allowed to come to an equilibrium condition during a week's exposure at 73° F. and 50% RH. Tensile, impact, dimensional, and weight properties were then measured.

Figure 7 gives the effect of extreme exposure on the ultimate tensile strength of nylon. All the curves show that nylon suffers a decrease in tensile strength due to the exposure.

Figure 8 portrays the percent elongation vs. exposure time. These curves merely show a trend because the elongation variance of nylon from specimen to specimen is quite great, ranging from 50% to 300% on normal specimens. This fall-off in elongation, if true, could be due to the oxidation of nylon, since storage was in air, but since too few specimens were tested to

Figure 9. Nylon (zytel 101) % moisture gained vs. exposure time.

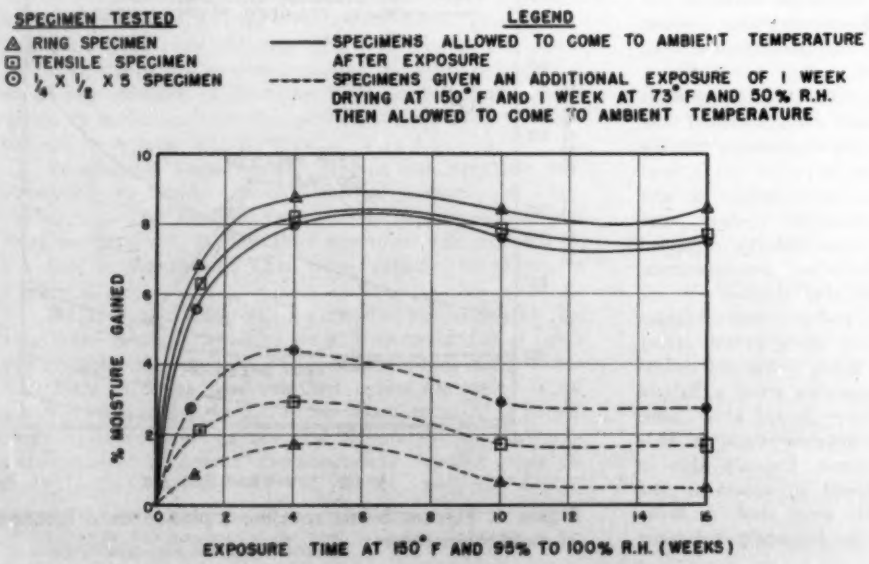
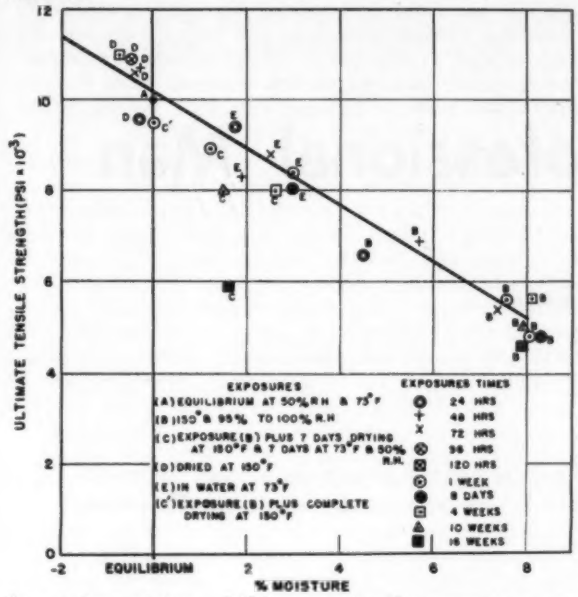

SPECIMEN TESTED
△ RING SPECIMEN
□ TENSILE SPECIMEN
⊙ ¼ X ½ X 5 SPECIMEN
LEGEND
SPECIMENS ALLOWED TO COME TO AMBIENT TEMPERATURE AFTER EXPOSURE
SPECIMENS GIVEN AN ADDITIONAL EXPOSURE OF 1 WEEK DRYING AT 150° F AND 1 WEEK AT 73° F AND 50% R.H. THEN ALLOWED TO COME TO AMBIENT TEMPERATURE
% MOISTURE GAINED
EXPOSURE TIME AT 150° F AND 95% TO 100% R.H. (WEEKS)

Figure 10. Nylon (Zytel 101) tensile strength vs. percent moisture.



show a true picture of this property, the curves are presented merely to give the trend established.

Along with the other tests, moisture contents were taken. Figure 9 shows the percent moisture gained vs. exposure time. Three types of specimens were measured: the tensile bar, the ring specimen, and a ¼"x½"x5" bar. The wet specimens reached a moisture content of 8.3% in approximately two weeks and remained quite constant at this level. The equilibrium specimens, those dried and then allowed to come to equilibrium, show some slight variance in moisture content throughout the period. Apparently, the equilibrium condition had not been reached in the one-week period. This was later checked and found to be true.

The ultimate strength vs. moisture content (Figure 10) is a combination of the curves of Figures 7 and 9. Additional data are included to complete the curve. This curve indicates, with one exception (point c), that tensile strength is inversely dependent on moisture content and not on exposure time. The 10-week specimen, which was dried and then allowed to come to equilibrium, falls only slightly below the curve. The 16 weeks point definitely falls below the curve and warrants further study. This point indicates that something other than moisture is affecting tensile strength. Perhaps decomposition, oxidation or recrystallization of the nylon begins after 10 weeks or perhaps the point is in error. It is true, however, that up to and including 10 weeks, no effect other than the moisture effect is seen on the tensile strength of nylon.

Figure 11 is a curve of the impact strength vs. exposure time. These curves are as expected and one would surmise again that the results are due to moisture and testing temperature variations. The moisture effect again makes the material more ductile as characterized by impact strength except at low temperatures. No permanent degradation can be seen here.

The last figure (Figure 12) is a group of curves representing the effect of different exposures on the O. D. of the test ring. The ring in this case is molded onto a metal insert, which affects its dimensions somewhat. The most severe case is again the exposure of 150°F and 100% RH. These samples increased approximately 0.008 inches in diameter in one week. The moisture

Figure 11. Nylon (Zytel 101) impact strength vs. exposure time.

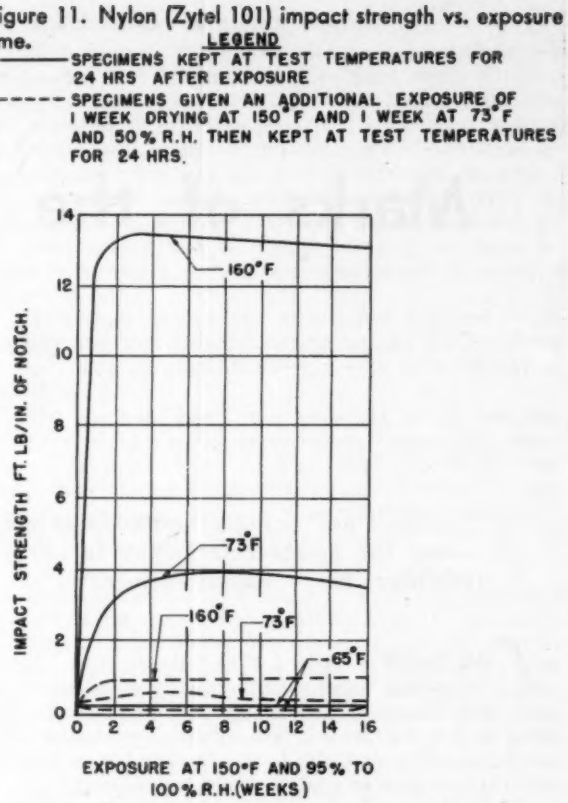
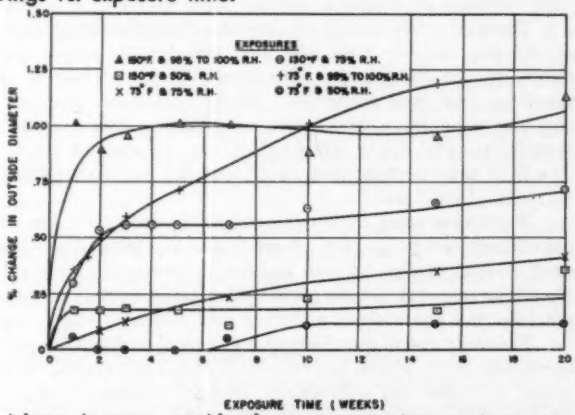

LEGEND
SPECIMENS KEPT AT TEST TEMPERATURES FOR 24 HRS AFTER EXPOSURE
SPECIMENS GIVEN AN ADDITIONAL EXPOSURE OF 1 WEEK DRYING AT 150°F AND 1 WEEK AT 73°F AND 50% R.H. THEN KEPT AT TEST TEMPERATURES FOR 24 HRS.
IMPACT STRENGTH FT. LB/IN. OF NOTCH.
160°F
73°F
160°F
73°F
-65°F
EXPOSURE AT 150°F AND 95% TO 100% R.H.(WEEKS)

Figure 12. Nylon (Zytel 101) changes in diameters of rings vs. exposure time.



pick-up is more rapid when exposure temperatures are high as seen by the other curves.

In summary, the use of a cold mold and good molding procedures enhances the toughness of nylon molded items and decreases the occurrence of brittle failures. A simple quality control test can be used to predict the performance of the end item and will discriminate between good and bad nylon as characterized by brittleness.

Nylon specimens exposed to storage conditions of 150°F. and 100% RH experienced a severe degradation of physical properties after one week of exposure. This degradation, other than percentage elongation, seems to be a temporary condition and is a function of the moisture present in the nylon. ★★

(1) Howard J. Starkweather, Jr., George E. Moore, John E. Hansen, Thomas M. Roder, and Richard E. Brooks, "Effect of Crystallinity on the Properties of Nylons," Journal of Polymer Science, Vol. XXI. pages 189-204 (1956)

Marks of the Professional Man

Clifford R. Rassweiler

Johns-Manville Corp.
New York, New York

. . . the "pro" is not a "professional man". This article stirred argument among chemists —but the points made apply to all "professions." As you read, substitute "plastics engineer" for "chemical engineer" . . .

FOR MANY YEARS I have followed with interest the efforts which chemists and chemical engineers have been making to gain recognition for their contributions to the welfare of this country—accomplishments which the public attributes to an abstraction it calls chemistry, rather than to professionally trained people.

Achieving professional status is one way of gaining greater individual recognition and one which is particularly popular in chemical circles.

There are two definite extremes of professional status. At one end we have the practitioners of one or the other of the "learned professions"—the professions of theology, law, and medicine. At the other end we have the men who have developed, by practice and training, certain specific skills which they use to earn a living. The first are "professional men," and the second are "professionals" or "pros."

From one point of view, it might be said that almost all of the various grades of professional status from the professional athlete at one end to the eminent jurist on the other can and do exist within the large groups of people who call themselves chemists and chemical engineers.

Probably most chemists and chemical engineers, even those who have a keen interest in professional status, have never analyzed the differences between various types of professional status. Neither have they clearly defined the kind of professional status they would like to have, the kind it is practical for them to achieve, and the price they are willing to pay in time and effort to achieve this status.

A Matter of Special Skill

In the first place, let us not pass over too quickly the advantages of being a "pro." It is true that a "pro" does not ordinarily command the social standing and respect usually accorded to a doctor or lawyer, but he often achieves a highly satisfactory economic status with a minimum of effort.

A "pro" is one who, by practice and training and repeated performance, has gained a high degree of skill at some specialized activity. This skill sets him apart from men who cannot match his accomplishment and, if it serves a useful purpose either in entertainment or in industry, he is likely to be well paid by people who require it. And one can become a "pro" with a relatively minor investment in formal education.

The "pro" may lose his skill if he does not practice it continuously, but the work for which he is paid usually supplies most or all of the practice required to maintain and improve skill. He needs to do little or no studying. The advantage of requiring minimum education and training, however, represents a major disadvantage, for the "pro's" skills are usually narrow and applicable only to specific purposes. His earning power is likely to advance rapidly at the start, reach a plateau from which it rises slowly as he grows older, and finally fall off sharply.

In spite of his limitations, however, the "pro" can be a valuable person and can take a great deal of pride in his status and his accomplishments. The term "pro" in our language is frequently used as a high compliment, for when we say a man is a real "pro" we mean that he has used his natural abilities in a highly skilled way.

The Chemical "Pro"

We must face the fact that many chemists and chemical engineers are "pros" and nothing more. By repeated practice and experience, they have become highly skilled in some particular chemical operation; but whatever breadth of knowledge and interest which their original education once provided has disappeared. Their limitations may be inadequate initial education, lack of personal ability, or an unwillingness to make the effort necessary to grow into any fuller professional status.

The large majority of chemists and chemical engineers, however, want to be more than just chemical "pros"; they strive for something comparable to the status of a practitioner of one of the learned professions.

What are the characteristics of the status they desire? And what can they, the scientific societies, or the universities do to help them reach this objective?

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One Difference Lies in Learning

The first difference between the "pro" and the professional man lies in the very term *learned* profession. The more desirable types of professional status gain stature because they demand an education which is materially greater than that required by other occupations.

As the professions of law and medicine have become more intricate and more complicated, the educational requirements for the prospective doctor or lawyer have become correspondingly higher and more rigid. Today, four years of college only qualify one to begin professional training in medicine and law. And we are rapidly approaching, if we have not already reached, the stage where a four-year college education is a mass production item, and one can no longer stand apart in our civilization as an especially learned individual simply by holding a bachelor's degree in chemistry or in chemical engineering.

Should we try to achieve professional status comparable to that of the lawyer and the doctor by placing greater and more obvious emphasis on the professional status of men with advanced graduate training, as opposed to men with simply a four-year degree? In the case of the lawyer and doctor, this additional preparation confers a title and a distinction which is retained throughout life. But there are very serious objections to making too great and too distinct a lifetime separation in the field of chemistry between those men with doctorates and those who have only bachelor's degrees.

The field of chemistry is extremely broad and in this broad range of activity initial training often becomes less important after a period of years than natural ability and self-education. So it is questionable whether an attempt to definitely stratify professional status in chemistry on the basis of initial education would be either desirable or practical.

On the other hand, the status of chemists and chemical engineers could be improved both in terms of prestige and remuneration if initial educational training and standards were gradually raised. The initial educational requirements in law and medicine have gradually risen from four to as many as eight years. In comparison, there is considerable question whether men taking a bachelor's degree in chemistry from many accredited schools know more than the men who took a similar degree from the same schools 20 years ago. The engineers, for example, are pushing the requirements in many schools to five years.

A Fifth Year?

It might be well worth while to consider adding a fifth year of training to the chemist's qualifications. If a proper curriculum were developed, one year of extra training could be tremendously valuable to the chemist or chemical engineer who is going into industry or teaching without a Ph. D.

Most universities do provide a fifth year of study leading to the Master of Science Degree. The work ordinarily included in this year of study, however, is usually simply the first part of the work required for a Ph.D. It is likely in most cases to be primarily an amplification of the same type of knowledge that the student has been acquiring as an undergraduate, rather than being designed toward a quite different objective of giving him the techniques necessary to put his chemical knowledge to use in industrial work or to impart his chemical knowledge successfully to others.

A Specialized, Terminal Degree

The master's degree, or perhaps a professional degree under another name, would be more useful if it were a terminal degree involving a specialized curriculum. For the chemists or chemical engineer going into industry, this extra year might involve the study of industrial organizations; the organization of experimental programs; the correlation, analysis, and presentation of data; the preparation and writing of reports; and a real grounding in the responsibilities and ethics which a man must assume to become a professional man instead of merely a "pro."

This extra year might even follow a period of actual employment. Many business schools are beginning to feel that their graduate programs are most effective at this stage.

For the man going into secondary school teaching, the year might include the training necessary for securing a teaching certificate. This might result in more high school science courses taught by scientists who are trained to teach, rather than by professional educators.

Keeping Up with the Literature

Continual self-education is another characteristic of the so-called learned professions. Initial education may give a man the title of doctor or lawyer, but if he is to be a respected and valuable practitioner of his profession, he is committed to the life-long task of "keeping up with the literature." The doctor who does not spend a good share of his evenings reading the latest medical journals can quickly become more of a harm than a benefit to his patients. The lawyer who does not continually take home a briefcase full of recent decisions rapidly drops to the point where he loses lawsuits.

This is one price of scientific professional status. After a period of years, the things the chemist and chemical engineer learned in college become less and less distinct and more and more obsolete. If they do not continually expand their scientific knowledge by self-education, their knowledge and skills become largely those concerned with their current jobs. Eventually, they retain little edge in knowledge over men who have been learning the same things in similar jobs but have no university training.

One of the quickest ways to identify a chemist as a professional man or a "pro" is to look for well-read scientific journals on his living room table, or to note if such journals are missing or filed unread in the family bookcase.

Willingness to Boost the Science

True professional status is also characterized by the willingness of professional men to work to advance their own profession or science. Professional men belong to professional and scientific societies, attend local and national meetings, and take part in committee activities. Also, scientists have always accepted responsibility for disseminating new information which advances the status of their profession. This involves not only financial contributions, but also a willingness to write, edit, and abstract technical papers.

Another way in which the professional man supports his calling is in helping schools to train new members. It is traditional in medicine that top-ranking doctors will take time from busy practices to lecture and conduct courses in medical schools, and the same policy is widely accepted by lawyers. Much of the professional attitude of graduates of the medical and law schools is probably the result of the personal efforts of men high in their

(Please turn to page 81)

Graft Copolymers

Norman G. Gaylord

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. . . graft and block copolymers are copolymers with the co-monomer units arranged in definite positions. These polymers offer exceptional possibilities for "tailor-made" properties and whole new families of resins. A second article will deal with the block copolymers . . .

MACROMOLECULES prepared from two different monomers may possess several alternate structures. For example, a vinyl copolymer prepared from equimolar proportions of two monomers may have either a regular (ordered) (I) or a random (disordered) (II) sequence.

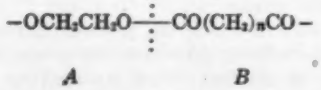
$$-ABABABABABABABABABAB-$$
I

$$-ABBBAABAAAAABBAAABBBBB-$$
II

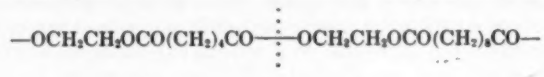
The sequence favored by a given pair of vinyl monomers is dependent upon the monomer structure and the influence of steric and polar factors upon monomer reactivity. Whereas sequence I is obtained in the copolymerization of styrene and acrylonitrile, or stilbene and maleic anhydride, sequence II occurs in the copolymerization of methyl acrylate and ethyl acrylate, or styrene and *p*-chlorostyrene.

The product of a condensation polymerization, of necessity, possesses the sequence I. Thus, the polymerization of ethylene glycol and adipic acid ($n=4$), or ethylene glycol and sebacic acid ($n=8$), yields the repeating unit III which leads to sequence I. However, the copolymerization of ethylene glycol with a mixture of adipic and sebacic acids corresponds to the copolymerization of ethylene adipate and ethylene sebacate (IV). Here *A* and *B* are larger units than in III and can lead to the random sequence II.

In sequences I and II, the macromolecules may have



III



IV

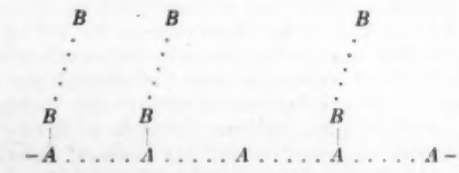
the same average molecular weight and the same chemical composition, and differ only in respect to the details of the arrangement of the two monomeric units in the chain. In both cases the alternations between *A* and *B* are frequent and occur over the range of a few Angstrom units. The properties of these copolymers are essentially an approximate average of the corresponding properties of the two components.

In addition to sequences I and II, a third type of copolymer of *A* and *B*, in which relatively long alternating stretches of *A* and *B* occur, can be visualized (V).

$$-AAAAAAAAAABBBBBBBBBBAAAAAAAAAA-$$
V

In this type of structure, called a block copolymer, the length of the uninterrupted stretches may range from a few to more than a hundred monomeric units. Where very large blocks are present, the properties may be similar to a mechanical mixture of the homopolymers poly–*A* and poly–*B*.

If we consider branching of the polymers, a fourth type of copolymer of *A* and *B* can be considered to be isomeric to I, II, and V. In this case the macromolecule consists of a backbone or trunk of poly–*A* with a relatively small number of branches of poly–*B* (VI).



VI

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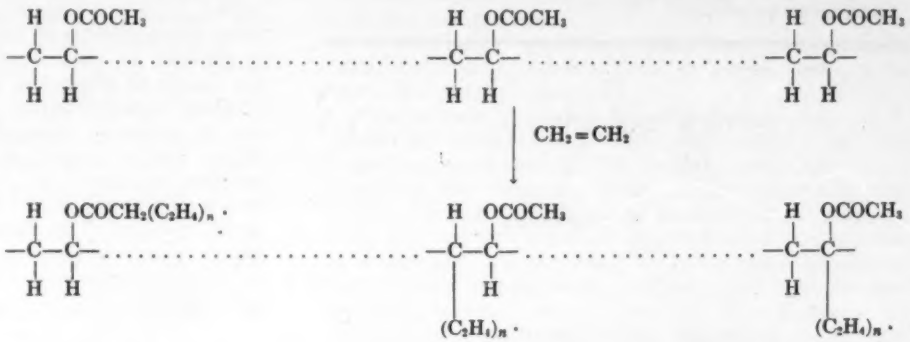
Interchemical Corp., 432 W. 45th St. New York 36, N. Y.

This structure has been called a graft copolymer, and in this case as well as with the block copolymer, although the molar ratio and the total molecular weight or degree of polymerization are kept constant, the length of the uninterrupted sequences of *A* and *B* can be varied to yield an entire spectrum of copolymer structures.

This article is concerned with the preparation and properties of the last type of macromolecule, the graft copolymer.



VIII

Grafting With Vinyl Monomers

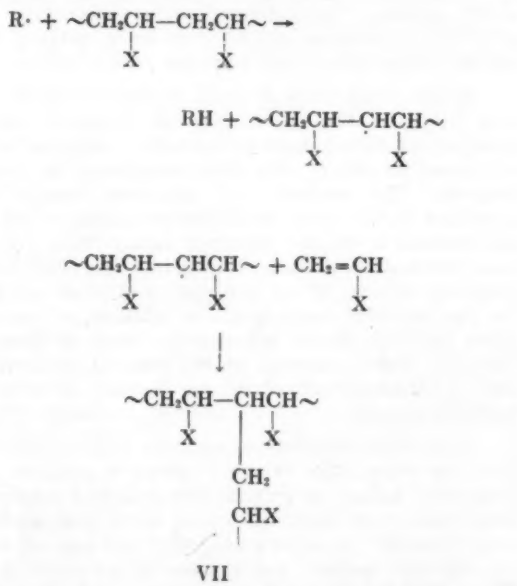
Two general methods have been utilized for the preparation of graft copolymers from vinyl monomers:

(a) Polymerization of a monomer in the presence of a polymer so that the growth of branches is initiated by chain transfer, and

(b) Polymerization of a monomer in the presence of a polymer containing reactive groups or positions which are capable of being activated to initiate the growth of sidechains.

Initiation by Chain Transfer

The process of chain transfer wherein a free radical, such as in a growing chain or arising from the decomposition of a polymerization catalyst, abstracts an atom such as hydrogen from a polymer chain to yield a free radical site for the growth of branches, is a fairly well recognized phenomenon. This reaction is considered to be responsible for the production of branched polymers in the polymerization of monomers such as ethylene, vinyl acetate, vinyl chloride, and acrylic esters (VII).



VII

The occurrence of a reaction between a monomer and a dead polymer chain has been confirmed by the use of radioactive tracer techniques. Thus, monomeric styrene labelled with carbon-14 has been polymerized in the presence of inactive polystyrene to yield polystyrene containing branches derived from the active monomer. Similarly, unlabelled vinyl acetate monomer has been polymerized in the presence of labelled polyvinyl acetate to yield an active polymer in which the sidechains are inactive *(3)*.

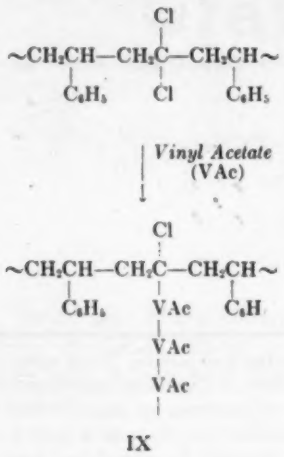
The success of the chain transfer method to produce graft copolymers depends upon the frequency of the chain transfer step as compared with the normal propagation step. The radioactive tracer studies indicate that transfer to polymer and branching are more significant in the case of polyvinyl acetate than in that of polystyrene.

Attempts to prepare graft copolymers by the chain transfer method, where the monomer to be grafted is different from the monomer in the backbone polymer, generally result in the formation of a heterogeneous mixture consisting of pure poly–*B*, resulting from homopolymerization of the second monomer, pure poly–*A*, from the original polymer which was not attacked by free radicals and therefore did not participate in the grafting reaction, and the graft copolymer containing branches of poly–*B* growing out of the backbone of poly–*A*. The mixture of polymers can generally be separated into the individual components by solvent extraction due to the different solubilities of the homopolymers and the graft copolymer. However, a clean fractionation and purification of the graft copolymer is not always possible.

The site of the growth of a branch will vary with the point of attack of the free radical on the polymer chain. This is illustrated by the results obtained in grafting polyethylene sidechains on a polyvinyl acetate backbone *(15)*. The polymerization of ethylene in the presence of polyvinyl acetate, using diethyl peroxide as the catalyst in benzene solution, gave a modified polyvinyl acetate which after alkaline methanolysis yielded mixtures of long-chain fatty acids and ethylene-modified polyvinyl alcohols. The hydrolysis to long-chain fatty acids shows that chain transfer occurs on the acetoxy group of polyvinyl acetate to initiate the growth of polyethylene chains. The formation of ethylene-modified polyvinyl alcohol shows that chain transfer, and subsequent growth of polyethylene chains, occurs on the backbone carbon of polyvinyl acetate (VIII).

In addition to hydrogen atoms, chlorine atoms may be used as the chain transfer points. Thus, vinyl acetate has been polymerized in the presence of a styrene–vinylidene chloride copolymer to yield a copolymer with polyvinyl acetate branches (IX). Similarly, styrene has been polymerized in the presence of a copolymer of a maleic

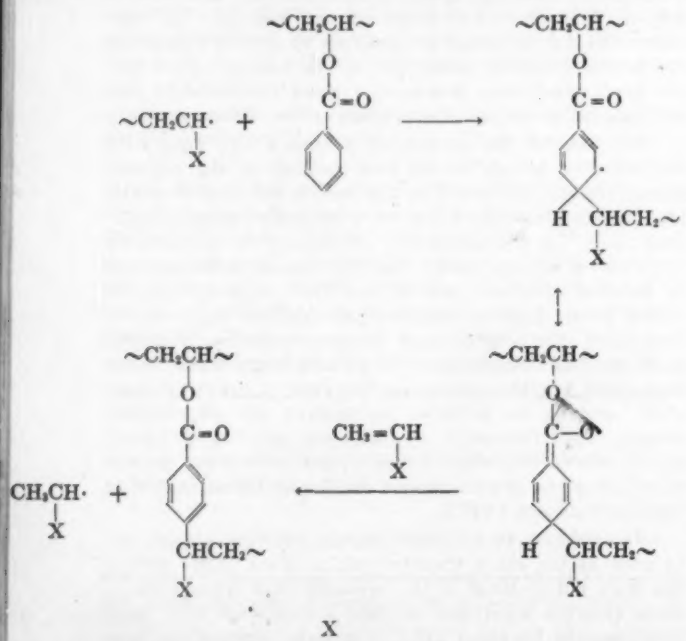
ester and vinyl trichloroacetate to give a copolymer with polystyrene sidechains.



IX

Treatment of cellulose with a mixture of acetic and 11-bromoundecanoic acids yields a mixed cellulose ester containing bromine atoms on the sidechain. The polymerization of styrene in the presence of this ester yields a graft copolymer due to the abstraction of the bromine atom and the growth of polystyrene on the resultant free radical.

The polymerization of vinyl benzoate is characterized by the formation of branched polymers arising from chain transfer reactions on the aromatic nucleus (X). This nuclear reactivity has been used in the grafting copolymerization of methyl methacrylate and vinyl acetate on the aromatic nuclei of polyvinyl benzoate in the presence of benzoyl peroxide *(18)*.



X

Although a polymer containing double bonds, e.g., rubber or a butadiene copolymer, possesses hydrogen or other atoms capable of being abstracted by a free radical to produce, by chain transfer, a free radical located on the polymeric chain, the double bond presents a site for addition copolymerization. Thus, in addition to the grafting of branches initiated from the highly susceptible allylic position or any other carbon atom on the chain, branches can grow by the addition of a free radical across the double bond followed by reaction with monomeric material. Therefore, grafting on an unsaturated backbone polymer is more complex than simple initiation by chain transfer and will be discussed separately in a later section.

Methods of Grafting

Graft copolymerization has been carried out in bulk, i.e., by dissolving the polymer and catalyst in the monomer, in solution, and in emulsion. Grafting in either bulk or solution has been carried out using benzoyl peroxide, azobisisobutyronitrile, or heat as the catalyst. By this method the following graft copolymers have been prepared: *p*-chlorostyrene on poly(methyl acrylate); methyl methacrylate, styrene, vinyl acetate, and vinyl chloride on poly(methyl methacrylate); and methyl methacrylate on polystyrene. Attempts to graft vinyl acetate on polystyrene and methyl methacrylate on polyvinyl acetate or polyvinyl chloride have been unsuccessful by this method. These results have been interpreted as indicating that after the formation of a macroradical by chain transfer the addition of monomer depends upon the reactivity and polarity of the monomer and consequently upon the stability of the derived radical.

Grafted acrylonitrile copolymers have been prepared by polymerizing acrylonitrile in water or acetonitrile solution in the presence of preformed polymers containing amide groups, e.g., acrylamides, itaconamides, maleamides, maleamates, fumaramates, and citraconamates. Various water-soluble polymers have been used as the backbone for acrylonitrile grafting, e.g., partially hydrolyzed polyvinyl acetate, polymethacrylamide, polyacrylic acid, polyvinyl pyrrolidone, polyethylene oxide, gelatin, starch, starch methyl ether, and cellulose methyl ether.

In the preparation of graft copolymers by the emulsion polymerization technique, the monomer and the catalyst, generally potassium persulfate, are added without additional emulsifier to a latex containing the backbone polymer. The omission of additional emulsifier is a critical factor since emulsifier would favor the homopolymerization of the monomer rather than the graft copolymerization. Although the patent literature contains numerous reports of the preparation of graft copolymers by the emulsion technique, the addition of emulsifier along with the second monomer in many of these cases indicates that a mixture of the original latex polymer and a homopolymer from the second monomer was probably formed.

A quantitative study of emulsion graft copolymerization has shown that whereas effective grafting occurs with vinyl acetate in polyvinyl chloride and polyacrylonitrile, very little grafting occurs with vinyl acetate or vinyl chloride on polystyrene, vinyl chloride or styrene on polyvinyl acetate, and styrene on polyvinyl chloride. The efficiency of grafting decreases with the addition of dodecyl mercaptan or a decrease in the temperature of polymerization. This supports a transfer mechanism, since a strong transfer agent competes with the polymer

for the free radicals and a decrease in temperature reduces the chain transfer tendencies. The efficiency of grafting increases with an increase in persulfate concentration, indicating that the transfer reaction with the polymer may proceed more rapidly with the free radical derived from the catalyst than with the growing polymer chain. However, a very sharp decrease in efficiency occurs when a persulfate-bisulfite catalyst-activator system is used in place of persulfate alone. Retardation occurs in polymerizations involving vinyl acetate and vinyl chloride monomers and polystyrene *(9)*.

Styrene-butadiene graft copolymers have been prepared by polymerizing styrene in aqueous emulsion until at least 90 per cent of the styrene was converted to polystyrene, then adding butadiene and completing the polymerization.

Grafted acrylonitrile copolymers have been prepared by polymerizing acrylonitrile in emulsion in the presence of polymers derived from monomers containing amide groups, such as acrylamide and N-vinylsuccinimide.

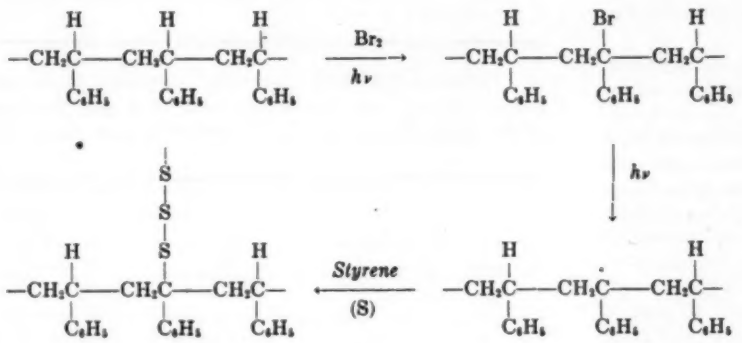
Suspension polymerization of vinyl acetate is generally carried out using polyvinyl alcohol as a suspension stabilizer. Considerable grafting of vinyl acetate upon polyvinyl alcohol occurs in this process.

Initiation by Activation

A number of graft copolymers have been prepared using radiation of various types to produce active sites on the backbone polymer.

Polystyrene in carbon tetrachloride has been photochemically brominated at room temperature until the bromide content rose to 5 to 10 per cent. Under these conditions the bromine atoms replace essentially the tertiary hydrogen atoms on the backbone of the polymer. The brominated polymer was dissolved in styrene monomer and the solution irradiated with ultraviolet light of such a wavelength that the bromine atoms were removed, leaving radical sites on the backbone of the polymer which initiated the polymerization of the monomeric styrene to form branches (XI) *(10)*.

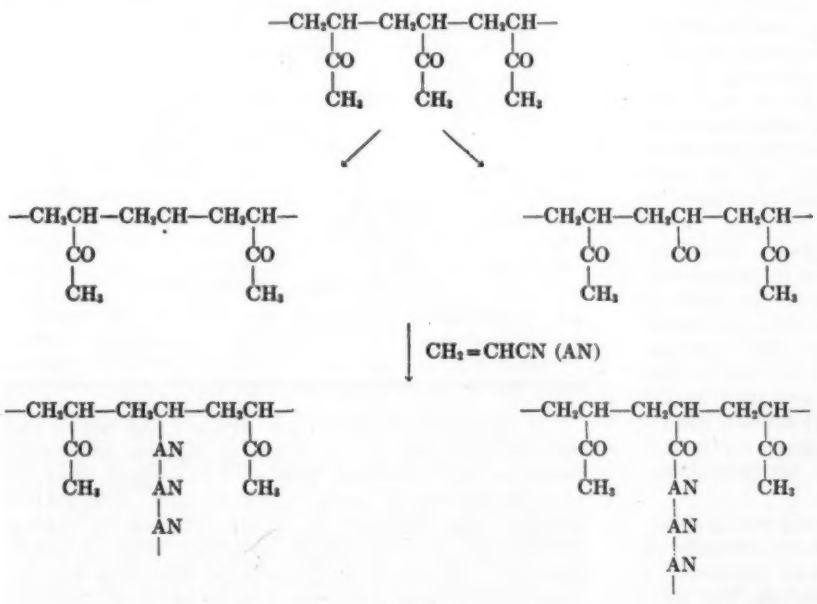
Ultraviolet irradiation has also been used in the graft copolymerization of acrylonitrile monomer with poly(methyl vinyl ketone) *(6)*. The polymer was dissolved in the monomer and irradiated to yield a polymer containing 54 per cent acrylonitrile. In the absence of poly(methly vinyl ketone), monomeric acrylonitrile was not polymerized on irradiation. Based on the known behavior of aliphatic ketones on photolysis the initiation of polymerization of acrylonitrile can be attributed to two different radical sites (XII). Methyl methacrylate and vinyl acetate have also been grafted on poly(methyl vinyl ketone). By using copolymers containing relatively few ketone groups it is possible to synthesize graft copolymers with a wide range of chemical compositions.



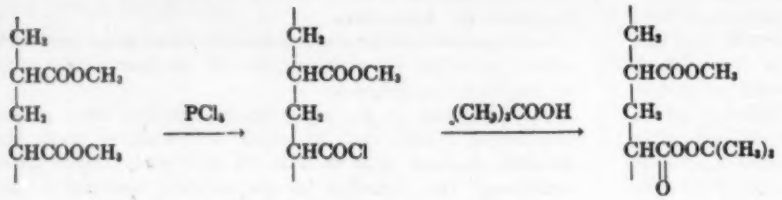
XI

Graft copolymers have been prepared by irradiation with gamma rays from a cobalt 60 source (2). By this technique, styrene has been grafted on poly (methyl methacrylate), poly (2,5-dichlorostyrene), poly(tetrafluoroethylene) (Teflon), poly (trifluorochlorethylene) (Kel-F), polyethylene, and crystalline polypropylene; acrylonitrile has been grafted on polyethylene and Hevea natural rubber; and methyl methacrylate has been grafted on dimenthyl siloxane. The grafting of styrene and acrylonitrile on polyethylene was carried out by immersing a polymeric film in a large volume of the monomer and irradiating the entire system.

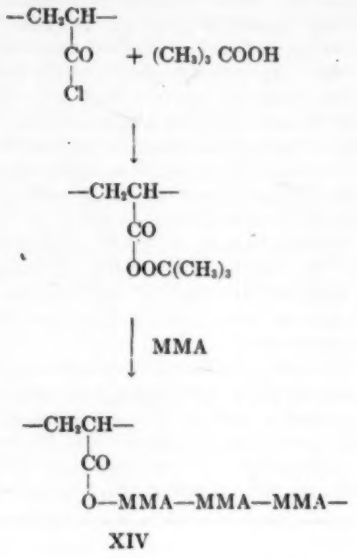
As a result of the irradiation-induced grafting on polyethylene various property changes occur. Acrylonitrile greatly reduces the swelling in and permeability to aromatic hydrocarbons while raising the softening range from 110° to 160°C. and providing for excellent adhesion to many polar materials. Vinyl carbazole maintains superior electrical properties while stiffening the polyethylene and raising the softening point to 215°C. Acrylic esters, even in quantities as small as 2 to 3 per cent, after hydrolysis produce a permanent surface con-



XII



XIII



XIV

ductivity and prevent the accumulation of static charges, while providing for good adhesion to substances such as cellulose, glass, and metals. Styrene increases the melt viscosity although it decreases the tensile strength and elongation of the polyethylene. The styrene-grafted polyethylene can be sulfonated to yield a cation-exchange membrane.

Styrene grafted on Teflon and Kel-F improves adhesion, prevents plastic flow, and increases the ultimate strength.

The thermal depolymerization of poly(tetrafluoroethylene) proceeds by a free radical mechanism. Since thermal decomposition in a poor conductor can be localized on the surface by a rapid heating process, a high concentration of free radicals in the surface layer can be formed with little decomposition in the bulk. This method has been utilized to produce graft copolymers of styrene on poly(tetrafluoroethylene). The surface of a block of the polymer was heated *in vacuo* by means of radiant heat from a platinum filament close to the surface, and then immersed in styrene monomer to yield a layer of polystyrene grafted on the surface of the poly(tetrafluoroethylene).

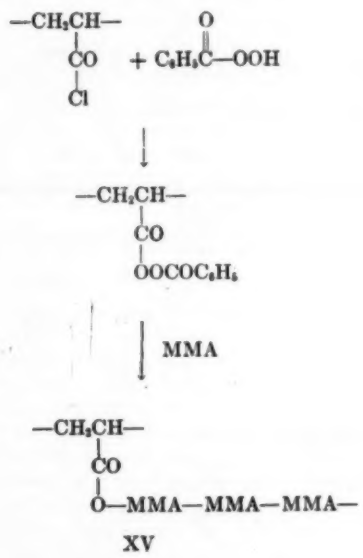
Initiation from Reactive Sites

The synthesis of polymers containing reactive groups which can be thermally or chemically activated to yield free radicals permits the initiation of grafting at the site of these groups. An essential feature of this type of grafting is that the initiation of polymerization occurs only at these reactive sites, eliminating the formation of polymer from the second monomer, i.e., no pure poly–*B* is formed and the product contains branches of *B* out of the backbone of poly–*A*.

The perester of poly(methyl acrylate) has been synthesized by treating the polymer with phosphorus pentachloride in benzene to form 25 to 26 per cent of the acid chloride, followed by treatment with *tert.* butylhydroperoxide in the presence of base. The resultant poly(methyl acrylate) contained about 5 per cent of the perester (XIII). The polyacrylic ester was used as the polymerization catalyst for styrene, vinyl acetate, methyl acrylate, and acrylonitrile to produce graft copolymers of these monomers on the poly(methyl acrylate) backbone.

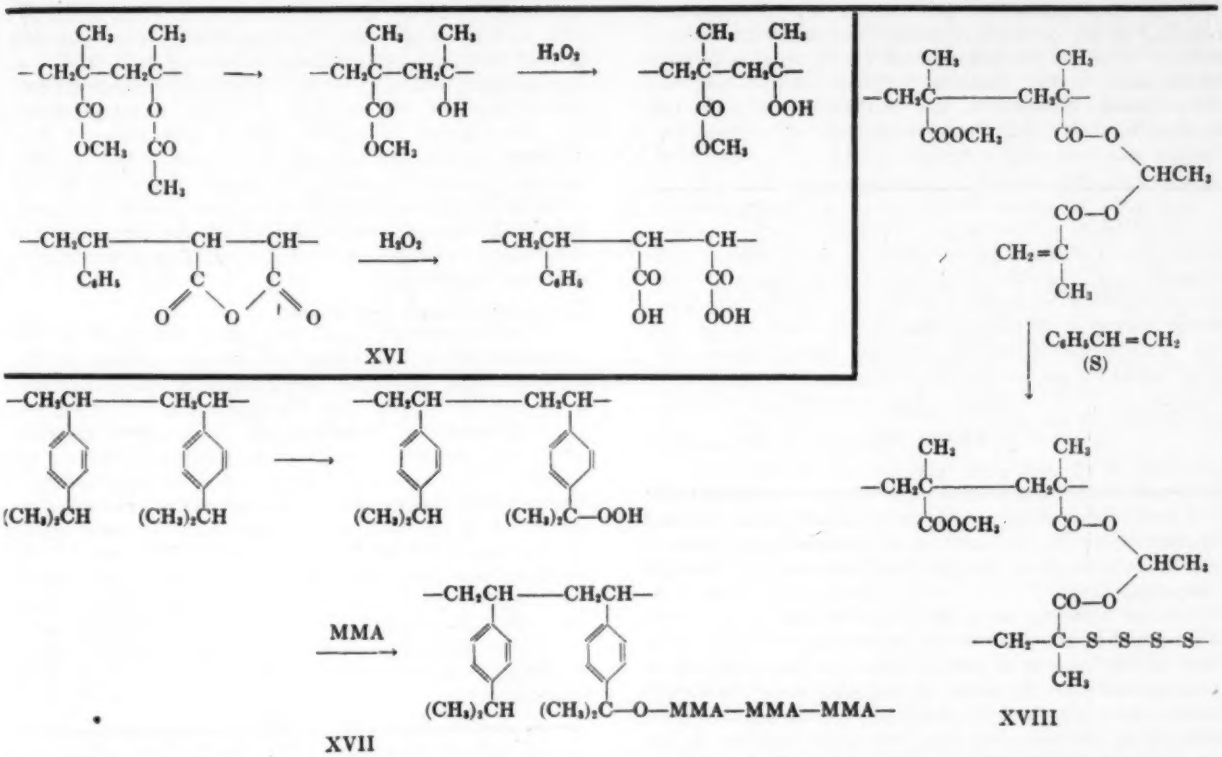
An analogous reaction has been carried out by treating polyacrylyl chloride with *tert.* butylhydroperoxide. In this case the polymeric acid chloride was prepared by polymerization of monomeric acrylyl chloride. The polyacrylic–*tert.* butyl perester was used as an initiator in the graft polymerization of methyl methacrylate (XIV).

Polyacrylyl-benzoyl peroxide, prepared from polyacrylyl chloride and perbenzoic acid, has also been used in the graft polymerization of methyl methacrylate (XV).



XV

A copolymer of methyl methacrylate and isopropenyl hydroperoxide and a copolymer of styrene and monopermaleic acid have also been used to initiate sidechain copolymerization of methyl methacrylate. The former initiator was prepared by copolymerization of methyl methacrylate and isopropenyl acetate, followed by hydrolysis and treatment with hydrogen peroxide. The styrene–monopermaleic acid copolymer was prepared by treatment of the styrene–maleic anhydride copolymer with hydrogen peroxide (XVI).



XVI

XVII

XVIII

Poly(isopropylstyrene), prepared by polymerization of *p*-isopropylstyrene or by a Friedel-Crafts reaction of polystyrene with isopropyl chloride in the presence of aluminum chloride, is readily converted in part to the hydroperoxide by bubbling in oxygen in the presence of benzoyl peroxide. The polymer containing hydroperoxide groups has been used as an initiator in the bulk polymerization of styrene and methyl methacrylate and in the ferrous ion–activated emulsion polymerization of methyl methacrylate (XVII) *(8, 14)*.

When the *o*-chlorobenzyl ester of cellulose is allowed to stand in air, peroxide groups are introduced into the polymeric molecule. The peroxide groups can serve as the site for the initiation of styrene polymerization to yield graft copolymers.

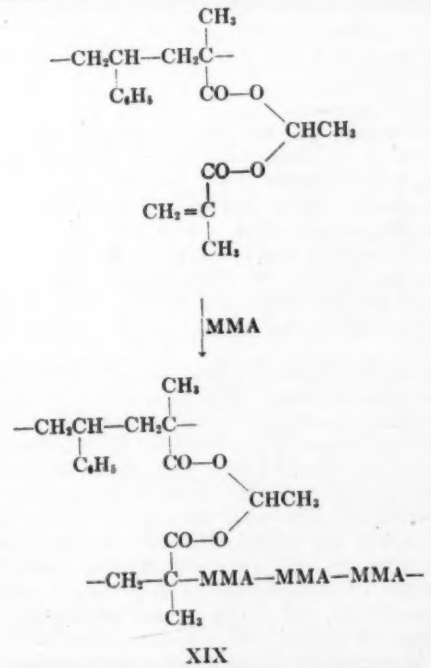
Initiation on Unsaturated Polymer

An unsaturated polymer presents two separate sites for the growth of a branch or graft. The carbon atoms alpha to the double bond are particularly reactive and susceptible to attack by a free radical and, by chain transfer, yield sites for grafting. In addition, the double bond can copolymerize with a vinyl monomer and thus serve as the site for branch growth. Crosslinking and gelation result from the incorporation of more than one double in a given branch. Crosslinking may also occur by the coupling of two branches, on different backbone macromolecules, particularly in the case of styrene monomer whose polymerization terminates by recombination.

Grafting on Unsaturated Polymer by Addition Copolymerization

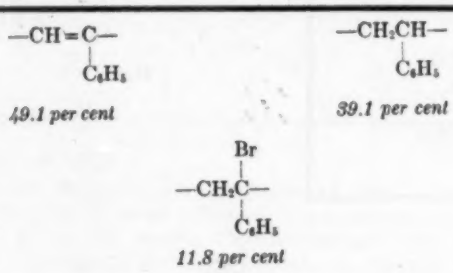
A soluble polymer containing residual double bonds on the sidechain has been obtained by copolymerizing methyl methacrylate with ethylidene dimethacrylate in solution in a 200 to 1 molar ratio, and carrying the reaction to less than 40 per cent conversion. By polymerizing ethyl acrylate and styrene in the presence of this unsaturated methyl methacrylate copolymer, graft copolymers were obtained by addition copolymerization (XVIII) *(17)*.

In a similar manner a soluble backbone polymer has been prepared by the copolymerization of styrene and ethylidene dimethacrylate in a 200 to 1 molar ratio. A graft copolymer was prepared by the polymerization of methyl methacrylate in the presence of this unsaturated polymer (XIX).



XIX

The bromination of polystyrene with N-bromosuccinimide in the presence of benzoyl peroxide has given a polymer in which 61 per cent of the styrene units were brominated on the backbone carbon chain. Treatment of a benzene solution of the brominated polymer with sodium butylate gave a debrominated polystyrene containing the following structural units (XX):



XX

Other proportions of these structures were obtained by decreasing the amount of bromination and varying the concentration of sodium butylate and the reaction temperature.

Vinyl acetate was grafted on the backbone of the debrominated polystyrene by refluxing a benzene solution of the monomer and polymer in the presence of benzoyl peroxide. In view of the previously mentioned unsuccessful attempts to graft vinyl acetate on polystyrene, it is probable that the successful grafting in this case was not due to the abstraction of bromine or hydrogen in the second and last structures above, respectively, but resulted from copolymerization of vinyl acetate and the double bond in the unsaturated polymer *(16)*.

Grafting on various natural polymers has been carried out by incorporating unsaturated groups on the polymer. The reaction of starch with allyl chloride in the presence of alkali yields the unsaturated ether allyl starch. The copolymerization of allyl starch with styrene in the presence of cumene hydroperoxide yields the graft copolymer, styrenated allyl starch. In order to reduce crosslinking only a few allyl groups are built onto the starch molecule.

Graft on to Cellulose

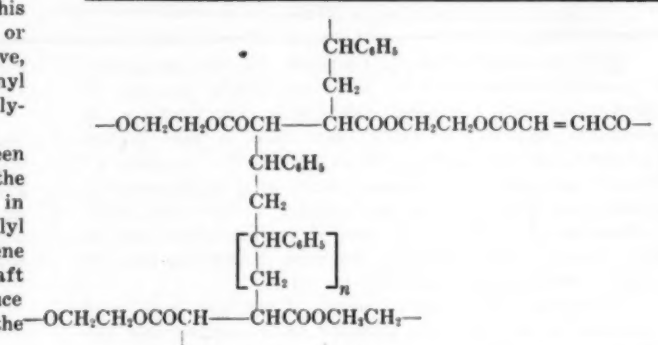
Graft copolymers have been prepared in an analogous manner on a cellulose backbone. Treatment of ethylcellulose with ethylene oxide followed by dehydration of the resultant hydroxyethyl derivative yields ethyl/vinylcellulose. Reaction of this unsaturated polymer with a maleic ester yields a graft copolymer. Ethyl/allylcellulose, prepared by reaction of ethylcellulose with an allylic halide, and the methacrylic and crotonic esters of cellulose can also be used as the backbone polymer for the grafting operation.

Styrenated polyesters and alkyds and analogous products based on other vinyl monomers are representative of graft copolymers with commercial application. The backbone polymers are prepared by the condensation of unsaturated dibasic acids and saturated glycols or saturated dibasic acids and unsaturated glycols. Among the unsaturated acids used as such or in the form of the anhydrides are maleic, fumaric, itaconic, mesaconic, and *cis*-3,6-endomethylene-Δ^4-tetrahydrophthalic acids (the adduct of cyclopentadiene and maleic anhydride). 1,4-Butenediol has been used as the unsaturated glycol. In addition to styrene, vinyl acetate, acrylic and methacrylic esters, vinyl toluene and allyl compounds have been used in this application. Mixtures of monomers such as styrene and methyl methacrylate have been used as well as various difunctional monomers such as divinyl benzene and diallyl phthalate. The most commonly used system involves the styrenation of a maleic polyester.

The reaction of styrene with a polyester can yield a linear polymer by addition of styrene to the terminal maleate groups, a crosslinked graft copolymer by the addition of styrene to internal maleate groups, and polystyrene by homopolymerization of styrene monomer. The styrenated polyester undoubtedly contains a mixture of all these components.

Cross-linked Graft Copolymer

The crosslinked graft copolymer results from the incorporation of a number of maleate groups in the styrene chain (XXI). A crosslinked structure may also arise due to the fact that the polymerization of styrene is terminated by recombination. Thus, two polyester backbone polymers containing growing polystyrene branches may be coupled by the mutual termination of the growing chains. Where methyl methacrylate is used as the vinyl monomer in the preparation of these resins, crosslinking results from the copolymerization of the methacrylate with the maleate groups. Since methyl methacrylate polymers are terminated by disproportionation rather than recombination, the polyester-methacrylate copolymer probably contains numerous poly(methyl methacrylate) branches and corresponds to a true graft copolymer.

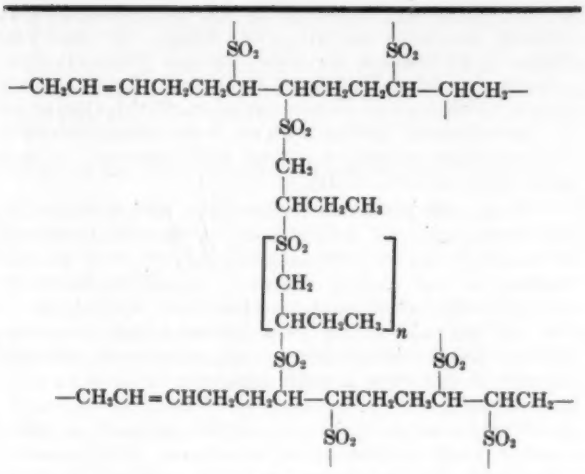


XXI

The use of a triol such as glycerol or trimethylolpropane in the preparation of a polyester permits the incorporation of sidechains in the polymer structure. In the presence of unsaturated monobasic acids derived from dehydrated castor oil, tung oil, linseed oil, soya oil, or cottonseed oil, the polyester contains unsaturated sidechains. The reaction of an unsaturated polyester or alkyd and a vinyl monomer such as styrene is analogous to the reaction of the maleic polyester to yield a crosslinked graft copolymer.

An epoxy or ethoxyline resin, prepared by the reaction of a bisphenol such as 2,2′-bis-(*p*-hydroxphenyl)-propane and epichlorohydrin in the presence of a base, can be reacted with drying oil acids to yield polymers with unsaturated sidechains. The copolymerization of the ethoxyline resin esters with a vinyl monomer yields a crosslinked graft copolymer.

An interesting type of graft copolymer has been prepared by the emulsion polymerization of sulfur dioxide and an olefin, such as 1-butene, 2-butene, or 1-octene, in the presence of a low molecular weight liquid polybutadiene using lithium nitrate as catalyst (XXII) *(11)*.



XXII

Grafting on Unsaturated Polymer by Addition Copolymerization and/or Chain Transfer

In the case of an unsaturated polymer such as rubber, polybutadiene, or a butadiene copolymer, graft copolymerization is not restricted to either initiation by chain transfer or addition across the double bond but apparently involves a combination of the two initiation sites or a hitherto uncharacterized mechanism.

Graft copolymerization on natural rubber has been carried out in bulk, for example, on a rubber mill, in solution, and in the latex.

Some of the earliest work on the reaction of a vinyl monomer and rubber involved maleic anhydride. Since the latter is capable of copolymerization but not homopolymerization, it is not possible to add more than one monomer unit for each site of attack on the rubber molecule. The product is therefore not a true graft on the backbone polymer but is more allied, at least at higher maleic anhydride content, to a block copolymer with the anhydride acting as a bridging unit between rubber molecules.

In the case of a vinyl monomer which is capable of homopolymerization, the configurations are somewhat more complex. The bridges between molecules of rubber can be of different lengths and the grafts may be true branches rather than bridges.

A quantitative study of the polymerization of methyl methacrylate and styrene in the presence of rubber has been carried out in benzene solution with benzoyl peroxide and azobisisobutyronitrile as catalysts *(12)*. With peroxide catalysis, the total product in the case of methyl methacrylate consisted of a mixture of unmodified free rubber, graft polymer, i.e., rubber containing bound methyl methacrylate, and free poly(methyl methacrylate). It was initially reported that the graft copolymer contained numerous very short chains of vinyl polymer. Thus, a rubber backbone polymer with a molecular weight of 270,000 reportedly contained many methyl methacrylate chains, each with a molecular weight of approximately 5,000. At the same time the free poly(methyl methacrylate) grew to approximately the chain length predicted by simple chain transfer theory, i.e., 185,000. However, more recent results indicate that the free and grafted vinyl polymer chains grow to approximately the same length, the early results arising from the solubilization of free rubber into the fraction containing the graft polymer *(13)*.

Graft copolymerization of styrene on rubber with benzoyl peroxide in benzene solution gave analogous results to those obtained with methyl methacrylate. When the reaction of rubber with either methyl methacrylate or styrene was carried out in benzene solution with azobisisobutyronitrile as catalyst, there was little or no grafting.

The literature contains numerous references to the polymerization of various vinyl monomers dispersed in natural rubber latex. In order that a reaction should take place between the monomer and rubber, a low proportion of surface-active stabilizer was used, and adequate time was allowed for diffusion of monomer into the rubber so that most of the polymerization occurred within the swollen rubber particles. In the presence of a large amount of dispersing agent much of the monomer polymerized independently of the rubber.

Initiators for the Copolymerization

Persulfates, perborates, hydrogen peroxide, alkyl hydroperoxides, benzoyl peroxide, reduction-activated organic hydroperoxides, diazoaminobenzene, diazothioethers, and diazonium salts have been used to initiate polymerization of vinyl monomers in natural rubber latex. Reduction-activated hydroperoxides and hydroperoxides activated by polyethylene polyamine were especially suitable since they did not require deammoniation of the latex nor were they particularly sensitive to oxygen inhibition.

For specific monomers certain initiators were more effective than others in promoting polymerization and/or grafting. Thus, the preferred initiator for the preparation of graft polymers from styrene or methyl methacrylate was a polyamine-activated hydroperoxide. A dihydroxyacetone-ferrous ion-*tert.* butyl hydroperoxide system was effective with acrylonitrile and vinylidene chloride *(4)*.

Attempts to graft vinyl acetate on rubber have been unsuccessful due to the severe retardation of polymerization and the low reactivity of allyl radicals derived from the rubber towards this monomer. The presence of high proportions of emulsifying agent has permitted the polymerization of vinyl acetate in rubber latex to give a mixed product indistinguishable from that obtained by blending a rubber latex and a polyvinyl acetate emulsion.

Graft copolymers of styrene and methyl methacrylate with rubber can be readily compounded to give light-colored articles of high tensile strength. The rubber–methyl methacrylate polymer shows reduced hysteresis and outstanding resistance to flex cracking and fatigue. Higher methacrylates give less reinforcement as the size of the ester group is increased. Acrylates behave similarly to methacrylates in giving good yields of graft copolymers in the presence of rubber, but the products are different in that snappy, insoluble materials are obtained which appear to be quite heavily crosslinked.

When a divinyl monomer is added to the styrene or methyl methacrylate used in grafting, the modified polymers are hard and possess more tear resistance than the unmodified graft polymers.

Styrene, ethyl acrylate, methyl methacrylate and various other vinyl monomers have been polymerized in the presence of gel-free butadiene polymers and copolymers in latex form to produce graft copolymers. If the homopolymers of the vinyl monomer were hard and resinous, e.g., styrene and methyl methacrylate, the grafts stiffened the stock polymers, and if the homopolymers were soft and elastic, e.g., ethyl acrylate, the grafts had little stiffening action. Methyl methacrylate grafted on a butadiene stock polymer or copolymer produced a

greater degree of reinforcement than an equal weight of styrene, which in turn produced more reinforcement than either mono- or dichlorostyrene. An interesting aspect of the grafting process in this case is that there is little tendency to crosslink the primary chains; the graft polymer can be prepared free from gel.

Butadiene-styrene graft copolymers have been prepared by first polymerizing butadiene in emulsion and then adding styrene or a butadiene-styrene mixture and polymerizing in the same emulsion. Similarly butadiene has been grafted on a butadiene-styrene copolymer. Butadiene-acrylonitrile graft copolymers have been prepared in an analogous manner.

Divinylbenzene has been copolymerized with a liquid polybutadiene to yield a solid thermosetting resin. Polybutadiene, prepared by emulsion polymerization, has been hydrogenated to reduce residual unsaturation and treated with acrylonitrile in the presence of benzoyl peroxide to yield a graft copolymer.

When rubber is masticated on a mill the applied shear ruptures the rubber molecules into free radicals. The radicals from chain rupture have been utilized to initiate the polymerization of a vinyl monomer present in the rubber being masticated, in the absence of oxygen *(1)*.

Methyl methacrylate and styrene polymerized during cold mastication of natural rubber sheet to yield interpolymers which were soluble up to complete polymerization. Benzoyl peroxide and azobisisobutyronitrile did not increase the rate of polymerization except during the induction period.

Chloroprene, acrylic acid, methacrylic acid, methyl and ethyl acrylate, acrylonitrile, acrylamide, and divinylbenzene all polymerized on masticating with natural rubber to yield insoluble interpolymers.

Polymerization of a mixture of methyl methacrylate and styrene in rubber gave polymerization behavior intermediate between that of the two separate monomers. With the approximately equal reactivity ratios in the system, the composition of the product formed was approximately that of the initial monomer mixture added to the rubber.

Polymerization of methyl methacrylate–chloroprene in rubber showed a markedly different behavior. With the large difference in monomer reactivity ratios in this system the two monomers largely polymerized separately

The synthetic rubbers, e.g., neoprene, poly(butadiene-styrene), poly(butadiene-acrylonitrile), polyisobutylene, and ester-amide rubber, i.e., polyurethane rubber from a polyester and a diisocyanate, as commercially available, did not polymerize monomers on mastication but merely underwent degradation. However, after precipitation to remove antioxidant and a low molecular weight fraction, polymerization readily occurred on mastication with vinyl monomers.

As in the case of solution and latex copolymerization, vinyl acetate did not polymerize in masticating rubber.

The mastication of rubber in the presence of vinyl monomers actually produces a mixture of graft and block copolymers. The shear rupture of a rubber molecule would produce primary radicals and break the backbone chain. The reaction of these radicals with the vinyl monomer would produce block copolymers. However, these primary radicals can be terminated partly by abstraction of α-methylenic hydrogen atoms from rubber molecules. The resultant radicals can react with monomer to form graft copolymers (XXIII).

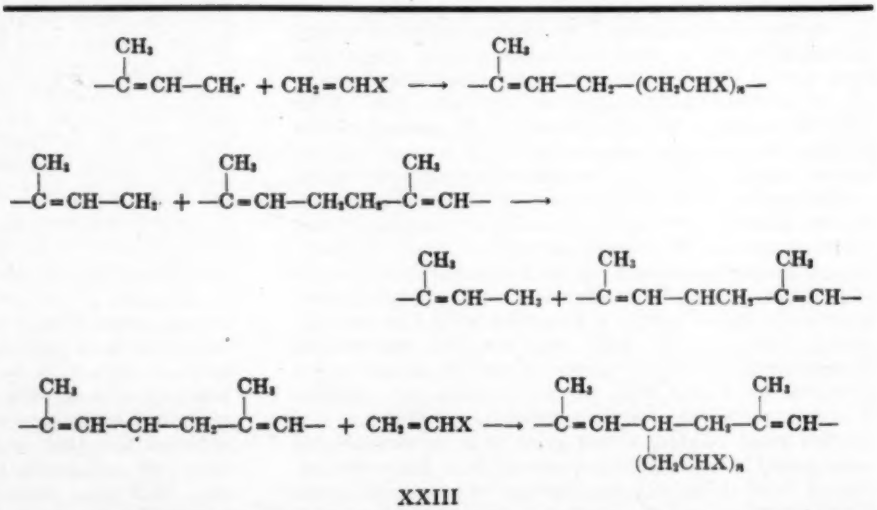
Block and graft copolymers have been prepared by cold mastication of mixtures of various elastomers as a result of the cross-termination of the free radicals formed by the milling operation. Copolymerization of natural rubber and neoprene has been carried out in this manner and it has been indicated that butadiene-styrene and butadiene-acrylonitrile copolymers are also capable of this type of graft copolymerization with other elastomers.

Proliferous or "popcorn" polymerization is a special case of graft polymerization wherein a vinyl monomer polymerizes in the presence of a crosslinked, insoluble polymer containing double bonds. Chains of the vinyl polymer become grafted onto the pre-existing polymer.

The formation of popcorn or "cauliflower" polymer from vinyl monomers requires the presence in them of a crosslinking, i.e., bifunctional, monomer. The copolymerization of the vinyl monomer with a small amount of the bifunctional monomer, e.g., the copolymerization of styrene with 0.2 to 2 per cent of divinylbenzene, may yield an insoluble polymer which occupies about three times the volume of the original liquid. Initially a few specks of solid polymer, containing residual unsaturation, appear. These specks of insoluble polymer imbibe styrene monomer which polymerizes so rapidly that substantially all of the monomer is consumed by the growth process before there is time for any appreciable quantity of normal polymer to form in the free liquid phase. The erratic expansion or "popping" of the insoluble polymer probably arises from the fact that the rate of formation of new insoluble polymer exceeds the rate at which it can attain swelling equilibrium with remaining monomer.

The product of a popcorn polymerization will grow and produce more popcorn polymer if it is placed in a monomer, not necessarily containing any crosslinking agent. The extent of this growth is determined by the amount of unsaturation in the seed polymer.

A variety of monomers in addition to styrene can be grafted onto the popcorn seed polymer. Different



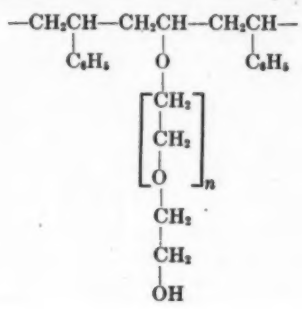
XXIII

monomers can be grafted onto the same seed, provided that at the conclusion of each step sufficient unsaturation is left in the seed for more growth. Thus, popcorn polyisoprene has been grown in methyl methacrylate monomer and the resultant polymer growth in styrene.

Grafting by Polyaddition or Condensation Reactions

The opening of an ethylene oxide ring by an active hydrogen such as in a hydroxyl or amide group permits the grafting of $(CH_2CH_2O)_n$ chains on a suitably substituted polymer.

The copolymerization of styrene with 1 to 2 mole per cent of vinyl acetate results in the formation of a polystyrene containing widely separated acetate groups. Hydrolysis of the acetate produces widely spaced hydroxyl groups which can serve to initiate a polyaddition reaction with ethylene oxide. The branches of the second monomer grow out exclusively from the original backbone polymer and no competitive homopolymer from the oxide is formed. A segment of the graft polymer can be represented as follows (XXIV):

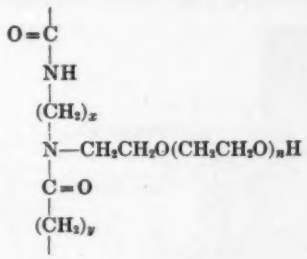


XXIV

A polymer of this type exhibits typical surface-active behavior. The macromolecule possesses water-soluble and oil-soluble segments. The segments derived from ethylene oxide are strongly solvated in water and keep the insoluble part of the polymer in stable suspension. If benzene is added to such a system it is accommodated in the oil-compatible polystyrene areas of the dispersed polymer molecules and we observe, as in the case of a detergent, solubilization of benzene in water. If the graft copolymer is placed in benzene, the oil-soluble polystyrene segments keep the macromolecule in solution and water can be solubilized in the hydrocarbon phase.

Ethylene oxide has been grafted on various superpolyamides and other amide-containing condensation polymers to produce a variety of "hydroxyethyl nylons" and related products *(7)*. 6-6 Nylon prepared from hexamethylenediamine and adipic acid, 6-nylon prepared from caprolactam, and a 6, 6-6, 6-10 interpolymer prepared from caprolactam, hexamethylenediamine, adipic acid, and sebacic acid, were treated with excess ethylene oxide in a stainless steel bomb. In some cases a diluent such as toluene or dioxane was used.

Up to 55 per cent ethylene oxide was grafted on the various nylon derivatives and in the case of the interpolymer more than 60 per cent ethylene oxide was introduced. In all of the hydroxethylated nylon-like materials, limited substitution of the backbone occurred, and a fairly high average length for polyethylene glycol branches was obtained. This was attributed to the fact that the reactivity of the generated primary hydroxyl group is greater than that of the amide hydrogen toward ethylene oxide (XXV).



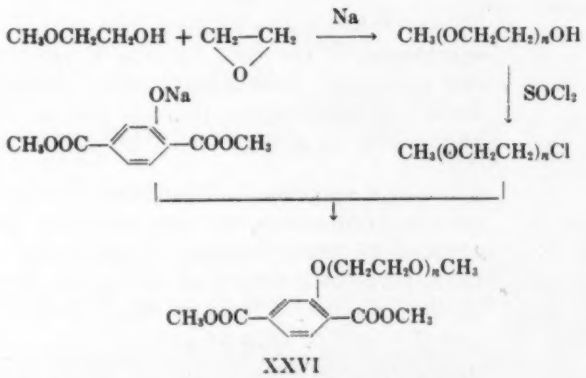
XXV

Instead of possessing the intermediate properties of a random copolymer, these materials retain the individual properties of the two species. Thus they have the solubility and high melting behavior of nylon, and the flexibility, second-order transition behavior, and hydrophilic nature of polyethylene oxides.

In addition to the nylon analogues discussed above, ethylene oxide was also grafted on methoxymethylated 6-6 nylon, a polyamide-sulfonamide interpolymer prepared from hexamethylene bis-ε-aminocaproic acid and hexamethylenediamine, a polyurea prepared from *m*-tolylene diisocyanate and hexamethylenediamine and an adipic acid/diglycolic acid/hexamethylenediamine nylon. In addition to ethylene oxide, propylene oxide, a mixture of ethylene oxide and propylene oxide, glycidol, glycidol acetate, epichlorohydrin, and ethylene carbonate were used as the branching monomer.

The reaction of cellulose with ethylene oxide yields a graft polymer consisting of a cellulose backbone and polyethylene oxide branches.

An interesting method of graft polymerization involves building the branch before the main chain. The monomer unit containing the branch has been prepared by the sequence of reactions shown below (XXVI). This

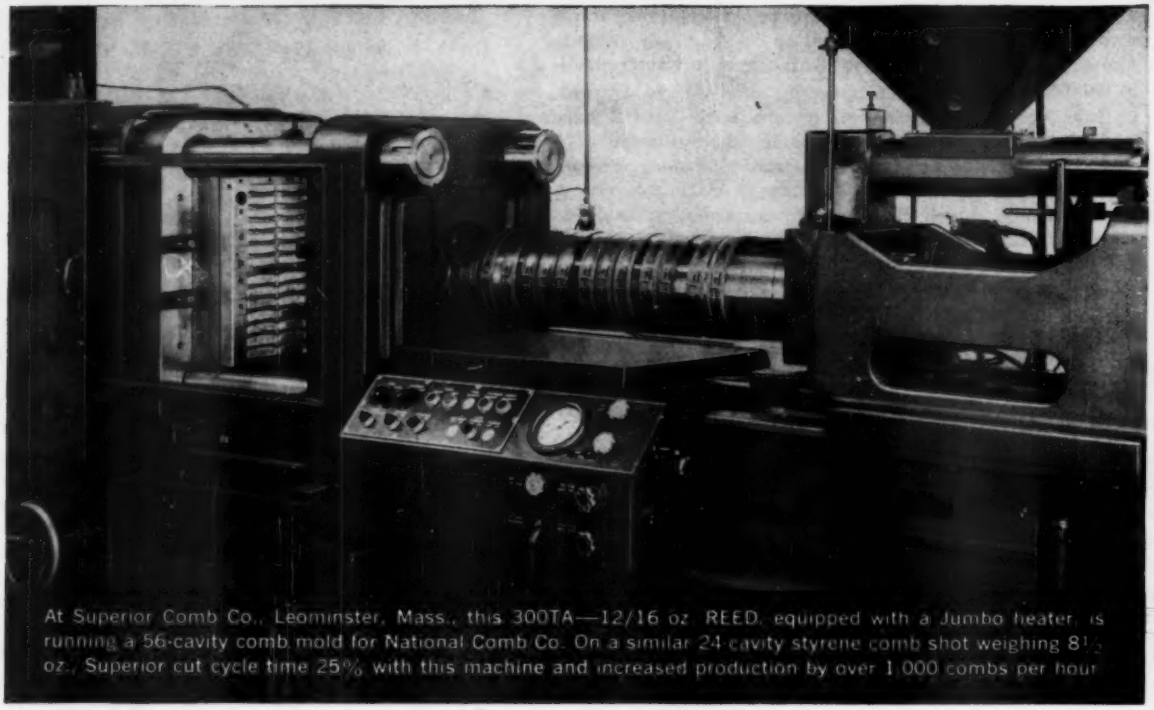


XXVI

ω-methylpolyoxyethylene 2-oxyterephthalate was heated with dimethyl terephthalate and ethylene glycol (with a trace of lead oxide as catalyst) to form the copolymer

(Please turn to page 80)

NEW REED JUMBO HEATERS...



At Superior Comb Co., Leominster, Mass., this 300TA—12/16 oz. REED, equipped with a Jumbo heater, is running a 56-cavity comb mold for National Comb Co. On a similar 24 cavity styrene comb shot weighing 8½ oz., Superior cut cycle time 25% with this machine and increased production by over 1,000 combs per hour.

Now available on New REEDS . . .

JUMBO HEATING CYLINDERS

This new REED Jumbo, available as optional equipment, is the best heating cylinder you can get today. Another product of advanced Reed-Prentice engineering, the Jumbo is the only heater to give you all these advantages:

Greater capacity — The Jumbo is big, and built to handle more material per hour. You're assured of fast, thorough plasticizing with close, three-zone temperature control. Shrink-fit construction of torpedo means better heat transfer, and no drag on fins.

Faster molding — You run heavier shots, fill the mold faster, and cut cycle time. The Jumbo operates at lower temperatures, helps you reduce curing time in the mold.

Leakproof construction — REED engineers have developed a new, three-piece construction for the Jumbo. This means you have *only two seams*, and far less chance of leakage than with other heating cylinders.

Easy to clean — Special features make it easier to remove, disassemble and clean the Jumbo when necessary. With this new REED heating cylinder, you lower your heater maintenance.

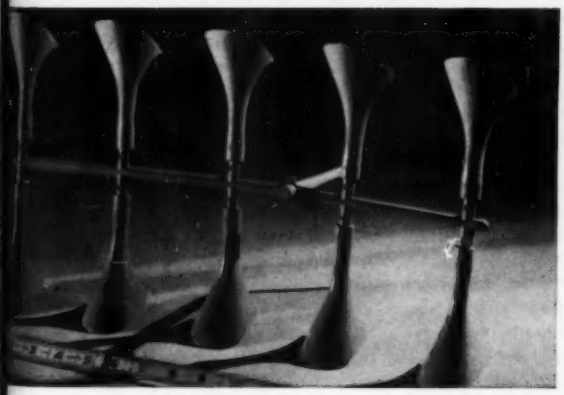
Jumbo heaters are available for these REEDS: 175T (and TL) — 4/6 oz.; 275T — 8/10 oz.; 300TA (and TL) — 12/16 oz.; 400 T — 16/20 oz. For further information, call your Reed-Prentice Sales Engineer today.

..ngineered for Modern Molding

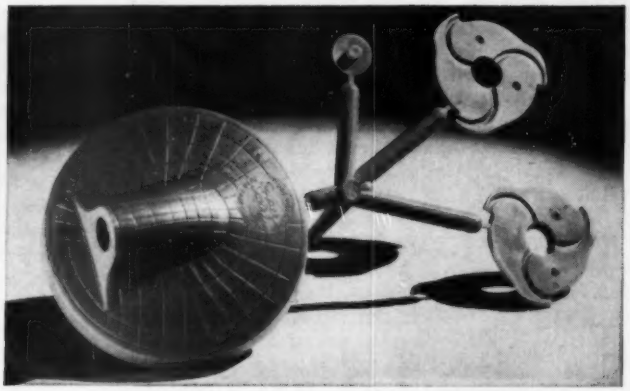
"WE'VE CHOSEN REEDS FOR OUR REPLACEMENT PROGRAM"

SAYS JOHN J. BACHNER,
President of Chicago Molded Products Corp.

"We focus our efforts on two main objectives — turning out superior molded parts and doing it in a way and at a price that saves money for our customers. We've built a reputation we're proud of on that policy. But we know we couldn't continue to do it, nor could we remain one of the country's top molders, with old equipment. That's why we have a program of planned machine replacement. Within the last year alone we've purchased six new REEDS in 4-, 8-, and 12-oz. capacities. These give us superior finished products, along with high production and low maintenance. Having watched these new REEDS perform for us, I don't see how any molder can satisfy customers today with outdated equipment."



This 10-cavity shot of ladies' shoe heels weighs 24 oz. in acetate. A 300TA—12/16 oz. REED equipped with the new Jumbo cylinder handles this job on a 65-second cycle.



Missouri Valley Plastics Co., Inc., Kansas City, Mo., uses a 175T—4/6 oz. REED, with built-in stuffing arrangement and Jumbo cylinder, to mold these auto washing brush parts. The 6½ oz., 4-cavity shot is high-impact styrene.

REED-PRENTICE

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Editor: Ernest P. Moslo

Verrill Norwood was born in Somerville, New Jersey, July 10, 1931. He earned his B.S. in Chemical Engineering at M.I.T. in 1953 and his M.S. in Chemical Engineering at the University of Michigan, 1954. He spent three years in the Packaging Division of Bakelite Company, Bound Brook, New Jersey and has done development work on heat-sealing problems and thin film fabrication. His community activities include Volunteer Fire Department, Junior Chamber of Commerce, Church.

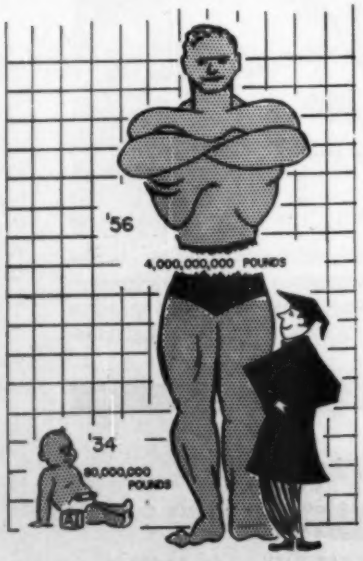
Verrill Norwood

A Career in Plastics

Editor's Note:

The college graduate has been in a rather unique position for the last few years. Not infrequently a college will have more companies giving employment interviews than it has graduates. The technical graduate, in particular, is likely to find himself in a good bargaining position and frequently can parlay his abilities into an excellent starting salary. Wise graduates, however, are not letting themselves be rushed; and they are asking searching questions of industry and of **themselves.** To provide the graduate with general knowledge of the problems with which he will be faced, we have asked a recent graduate to comment on career opportunities in one industry—the plastics industry. *(Ernest P. Moslo)*

The plastics industry is a rapidly expanding portion of the chemical industry and is most often used as an example of how entirely new fields can spring up in a decade and assume important and vital functions in our economy. The total production of plastics has risen from about 80 million pounds in 1936, to over four billion pounds in 1956, an increase of 5000%. In 25 years plastics will probably rank in the top four basic materials with steel, glass, and wood. This is from materials that were little known 20 years ago.



The Plastics Industry Has Grown.

This potential can be best illustrated by just looking up from this page and checking the amount of plastics used in the immediate vicinity, and more important, since plastics are still in their "infancy", the places where plastics **could be** used. In 1956, 700 million pounds of vinyl plastics were used in one form or another, and new uses are being found for this relatively "old" material everyday.

The production of plastics is expanding enormously. Since 1953 more than one-quarter billion dollars has been expended by manufacturers for materials and manpower. And the yearly expenditure is by no means being lessened. The need for chemical engineers, chemists and physicists to develop better resins is a crying one. And when the development workers improve a product, mechanical, electrical, and civil engineers are needed to build the equipment and plants in order to put the product "on stream".

A Round Peg in a Round Hole

The first man who tried to fit the round peg in the square hole wasn't an incompetent. He was searching—and had to learn. Recognizing that many college graduates, because of limited experience, are very like this man in "career desires", most of the large resin manufacturers offer a training period where the new employee can try a little of all types of work. But because of the vastness of the business, many of the training programs must be conducted entirely inside a particular phase of the operations. Here is where the graduate is asked to make

his choice. Will it be research, development, production, or marketing? These four basic components are found in almost any business, large or small. They are all interconnected and each depends for its existence and value on the other three.

Calling Card and Sliderule—Overalls and Fountain Pens

Probably the longest and most complicated training course provided by resin manufacturers is given to the sales trainee who will work in the field. Selling plastics is a long way from the "knock on any door" techniques used in some other industries. The complexities found in the composition and fabrication of synthetic resins almost dictate that the fieldman be a technically trained individual. The fact that he operates out of reach of reference books and experts makes it imperative that he know as much about his product and company as possible.

Frequently the field man not only has to sell a customer on a brand of resin, but also assist him in utilizing it most efficiently. Technical bulletins supplied by his advertising department provide him and his customer with the latest up-to-date data, but they must be interpreted for each specific problem and thoroughly understood before any benefit can be gained from them. Many of the larger basic resin manufacturers call their field men Technical Representatives or Technical Consultants, and they are just that, men who are technically trained in all avenues of plastics technology. They supply their company's product to the market, advise customers on usage, and assist in fabricating problems so that production may be maintained at full capacity; furthermore, they also advise their own development and research groups of happenings in the field and relay needs for new products.

Test Tubes and Beakers

Research in the plastics industry is usually working years ahead of the actual product being produced and sold. Our free enterprise system provides the competition that makes product improvement and new material discovery an absolute necessity, if the company is to maintain its position. Direction of the research activities may come from the marketing men, who see the need for a new product, or from the development work. which on occasion has actually created new substances. The research people may know from pure theory that a certain polymerization possesses properties very much in demand. They must then transpose the theory into a working process that will produce a product worth offering for sale. Seldom does the research group forget that its work and experimentation is made possible by the other three phases of their business, nor are they allowed to forget that without research the company's competitive position would deteriorate.

Supply and Search

The Development Group has a two-fold purpose. First, they must take the work the research people have done in a test tube and greatly multiply it into a giant plant capable of producing the substance in commercial quantities. Difficult at best, it is sometimes impossible.

Second, plastics already on the market are continually tested and modified to improve general properties or tailored to specific uses. For example, a problem arose when high speed automatic molding techniques were used for the manufacture of phenolic components and parts. The existing compounds would simply not cure fast enough to make full use of the automatic machinery. After many trials and much laboratory work, a new fast cure phenolic compound has been developed that will allow

The College student must consider carefully the opportunities in all four work areas.

the automatic machines to run at full speed. Advanced technology developed the automatic machines and advanced development work adapted an existing product for use with them. The field personnel are a chief source of new ideas for development work, and the development personnel must keep in close touch with both the production and research phase of manufacturing in order to provide new products and processes.

On Stream, Continuously, Efficiently

The most obvious phase of manufacturing is the actual production of the product.

In order that the essential development work and the research work can continue, a product must be maintained and the plant and equipment kept in top condition. Deliveries must be scheduled and shipped faithfully or the field personnel could not maintain the company's sales position. Much of the information utilized by the development phase is gleaned from actual production and many times development will provide methods for more efficient production.

The plastics industry is so new that opportunities in production are unlimited. One example of a production problem was created by the introduction of vinyl foam into the flexible foam market. The foam was being placed and cured in batch lots, each piece handled separately. As a result of co-operation between development and production, a process was developed whereby vinyl foam can now be produced in a continuous, never-ending slab.

Much of the administrative and supervisory work that is offered by a manufacturer falls under the production category, as do specialty fields like industrial relations, industrial safety, and personnel relations.

A World of Opportunity in A World of Plastics

Plastics is a booming business and will continue to grow. Of the basic materials—steel can be alloyed, glass can be tempered, and wood densified, but only when working with plastics can man actually alter the basic structure to suit his needs. Plastics did not exist in nature, they are man made and man controlled. Opportunities in the plastics industry are without number. A job-seeking college graduate might do well to remember that plastics is already a major industry and it is still on the ground floor. ★★

MOLDING CYCLES

Edited by Louis Paggi, *Consultant, du Pont de Nemours & Co., Inc.*

Molding Thick Sections

Louis Paggi

A thick section cannot be defined rigorously by dimensions alone. This is so because geometry of the part and type of plastic used play a very important role in establishing the molding conditions or mold design which would place an article in the category of having thin or thick sections. A good basis of comparison would be the difference in time required to build up back pressure at the cavity against the incoming material and thereby control the rate of filling of the cavity. If, regardless of rate of filling, the material dams up directly in front of the gate, and the pressure required to fill the cavity is high, the article may be considered as belonging in the thin section category. If at a high rate of filling of the mold the material jets into the cavity with little resistance to flow it may be considered as having thick sections.

Figure 1 shows two methods of gating the same part. In Figure 1 (a) the part is gated so that the material entering the cavity flows across the smaller dimension and immediately forms a dam in front of the gate. With this type of gate, the rate of filling is controlled, therefore the molding conditions will not be difficult to adjust. When the article is gated as shown in Figure 1 (b) molding conditions required for heavy sections will apply.

Turbulent flow into any cavity—regardless of design—is not desirable because it generally results in surface defects as well as erratic distribution of stresses. When an article having thin sections is molded, the material entering the cavity hugs the cavity walls thus building up back pressure permitting a controlled uniform rate of fill. This desirable condition is absent when molding articles with thick sections unless the viscosity of the material is high and/or the flow into the individual cavity is throttled.

The important variables involved when molding thick sections are:

1. Condition of the plastic
2. Temperature of the plastifying cylinder
3. Rate of filling of the mold
4. Pressure within the cavity
5. Cycle distribution
6. Gate design

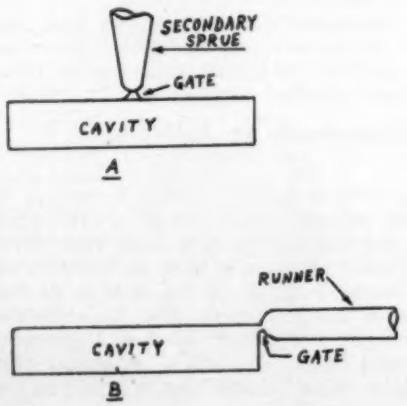


Figure 1. Method of Gating will Greatly Affect Molding Conditions.

Condition of the Material

At normal rates of mold filling the back pressure developed during the filling of the cavity is relatively low. Thus, there is a sudden drop in pressure across the gate and small percentages of low boiling compounds (such as water or solvents) present in the molten material may flash into vapor at the lower pressure. The gases formed will have ample time to gather at or near the surface of the melt and thus cause surface defects. The molding powder used, therefore, should be as free of volatile matter as it is practical to obtain. On the other hand, and depending on the type of plastic used, it should not be overdried to the point where desirable plasticizer is lost and degradation takes place at the necessary molding temperature.

Temperature of the Plasticizing Cylinder

Because of the need for a high viscosity melt and for building up resistance to flow within the cavity, the temperature of the shot zone of the plastifying cylinder will in most cases be relatively low. In order to eliminate sink marks and internal voids it will be necessary to build up high cavity pressure. These requirements make it important to have a high pressure at the entrance to the mold. Therefore, the pressure loss within the cylinder must be held to a minimum. This means operating with a rear cylinder temperature considerably higher than the shot zone temperature to reduce pressure drop as the melt moves toward the front of the cylinder. A difference of 100°F. between the front and rear zones of the cylinder is quite common.

Rate of Filling of the Mold

The rate of filling will vary with the problem at hand. For example, with certain materials the viscosity of the melt is not greatly affected by changes in temperature. When molding with these materials it may be necessary to build up back pressure within the cavity by fast injection. It may then be necessary to operate every zone of the plastifying cylinder at a relatively high temperature. If burning or charring of the surface becomes a problem, the cavity should be provided with generous venting rather than to attempt to slow down the filling rate.

With high viscosity melt the rate of filling should be slow and steady. The exact rate of filling for any job will be determined by the appearance of the surface of the molded article. If the surface of the article shows evidence of turbulent flow into the cavity the rate of filling is too fast. If, on the other hand, the surface

(Please turn to page 50)

SPEAKING OF EXTRUSION

Edited by R. D. Sackett
Technical Service Associate
Monsanto Chemical Company
Springfield, Massachusetts

Extrusion Coloring Natural Polyethylene

H. Segal

Celanese Corp. of America

Manufacturers of colored extruded polyethylene products have strong incentives for adding the necessary coloring agents during their processing rather than purchase colored resin. Colored resin, in small lots, may sell at a $.25 per pound premium above the cost of natural resin and up to a $.09 premium in large lots. The storage and rapid delivery of many colored resins involves supply difficulties which do not arise when using the natural resin plus suitable pigmentation. The present sales pattern reflects this situation and many resin suppliers do not sell colored resin.

There are colorant suppliers able to service organizations who do their own coloring but cannot justify their own color matching facilities and personnel. These suppliers do the required color matching and pigment processing; selling either in bulk or in preweighed units suitable for incorporation with a given weight of resin.

Pigments Are Used

Pigments are used almost exclusively in polyethylene because dyes are not compatible and exude to the surface. The pigment requirements for extrusion do not differ greatly from those involved in injection molding but the incorporation of the colorants with the resin presents somewhat different problems. Applicable techniques will be discussed below.

To understand the reasons why certain coloring techniques have been developed, the measures of product quality need to be discussed briefly. Good quality will be defined here as pigmentation which has been suspended in the end product in a finely divided state and has been uniformly distributed throughout. This indefinite qualitative standard has to be further defined either quantitatively or by comparison with reference samples for each specific application. However, it serves to illustrate the two quality parameters which generally govern. These are: (1) pigment dispersion (referring to final pigment particle size) and (2) uniformity of pigment distribution throughout the extrudate.

To Obtain Quality

To obtain requisite quality, variants of two conventional coloring systems are employed. The first system is broadly called dry coloring and consists essentially of tumbling the dry pigments with the natural pellets in a drum or suitable container. The pigment supplier may have pretreated the pigments with special oil or waxes to give some adhesive quality to the powder to keep it from dusting off the pellets. The pigments may also have been passed through some grinding process to reduce pigment agglomerates. In some cases, the supplier may recommend pretumbling the pellets with a special liquid for purposes of improving adhesion.

The second system involves mixing the pigments with a small amount of natural resin in a Banbury, in an extruder, or on a roll mill, producing an intermediate product designated as color concentrate. With this system the pigment is thoroughly dispersed and fixed in the resin, effectively eliminating the dusting problem and preventing reagglomeration of the pigment particles in later processing. The concentrate systems are usually arranged to employ 2 to 6% concentrate in the final mix. Color concentrates cost roughly about twice as much as dry pigments for equal colorant content except where the pigments used are particularly expensive.

For Extrusion

For the extrusion of natural polyethylene a certain minimum amount of mechanical work and mixing must be done by the screw to obtain a fully melted and homogeneous extrudate. In order to extrude with dry colors or concentrates and obtain acceptable quality, the amount of work and mixing must be increased. This becomes apparent when one considers the composition of the feed. Relatively large pieces of polyethylene (pellets) are covered with a fine pigment (in the case of dry colors) or mixed with pellets containing a concentration of pigment (in the case of concentrates). In either case, the resin feed must now be mixed until the pigment is uniformly distributed through the molten mass.

The major factor influencing mixing in the extrusion system is the screw. The best screw designs found to date are the conventional polyethylene screws being supplied as standard designs by the major extruder manufacturers or those incorporating "Dulmage" sections.

Use of Back Pressure

The mixing performance of the screw will improve with increased back pressure such as may be obtained by varying screen packs or increasing die restriction. However, there is a limit to how far one can go in this direction. A 100 mesh screen will pass most pigments, but high concentrations of titanium dioxide will quickly clog it. Screens finer than 100 mesh will start clogging with other pigments and with contaminants.

Extruder operating conditions used for natural extrusion are generally satisfactory for color extrusion. Extruder size also plays an important role in mixing the molten resin. Large diameter screws with the long barrel lengths provide high shear rates and a long mixing path. Both of these are assets. In one series of experiments a "standard" polyethylene screw in a 2½" extruder did not yield sufficient mixing to produce a satisfactorily uniform distribution, but the same screw design in a 6" extruder under comparable operating conditions, did.

In cases where an extruder with a desirable screw design does not perform adequately, there are additional aids available. Several extruder manufacturers have marketed mixing devices which attach to the front of the extruder. Tests on some of them have proven their utility. The devices are

Molding Cycles . . .

(Continued from page 48)

shows reticulation and poor welding, the rate of filling is too slow.

Pressure Within the Cavity.

The greater the mass of an article the greater will be the total shrinkage, therefore, surface distortion of a thick section will be more pronounced than that of a thin section when both are injection molded under identical cavity pressures. It is quite obvious that the cavity pressure developed during the molding of thick sections must be high. This often presents a problem with flashing unless the cavities are well supported and the clamp force provides at least five tons per square inch of projected shot area. The flashing can be controlled by the use of dual pumps, with individual pressure adjustment, fed to the injection cylinder. This system employs a low pressure pump to fill the mold, then, after a predetermined time the high pressure pump is brought into service by means of a timer. The delay in using the high pressure pump permits a hard shell to form around the article before the high pressure is reached, thus preventing flashing.

Cycle Distribution

In order to achieve effective cooling, it is necessary that good contact between the plastic and the cavity surface be maintained. Therefore, it is desirable to distribute time with the greatest percentage of cycle applied to pressure on the material. This distribution may occasionally result in ejection difficulties. When this occurs, it is advisable to consider slight mold alterations such as addition of or removal of under-cuts, increasing draft angles, altering gate design, draw polishing, etc., rather than to sacrifice cycle time or quality of the part.

Gate Design

A common error in the gating of thick sections is to make the gates too large. This is done with two objects in mind, namely:

1. To maintain pressure on the material and thus reduce the shrinkage which causes surface sinking or internal voids.
2. To cause the material to hug the cavity walls during filling of the cavity and thus avoid surface knit lines or fold marks.

Both of the above are valid reasons for large gates, but while they eliminate some problems, they also tend to introduce others. Chief among these is the tendency to reduce the back pressure in the runner system to the extent that control over the filling of the individual cavities is lost. Controlled filling of cavities with large gates can be maintained by the use of a restriction between each cavity and the branch runner feeding it. The tab gate as shown in Figure 2 is such a restriction. If the volume of the cavity is large the gate to the tab may be wide and thin. Failure to provide a thin gate to the tab will result in loss of back pressure in the runner system, poor blending of material and a high degree of stressing at the region of the gate.

The following tabulation is given to assist the molder in locating the source of common trouble when molding thick sections.

Problem and Probable Cause

Internal voids and sink marks—Pressure transmitted to the cavity too low. Ram forward time too short. Wrong type of gate. Material temperature too high. Rate of filling too fast.

Surface fold marks—Filling rate too fast. Insufficient radius at the outlet of the gate. Gate at junction to the cavity too small or in wrong position.

Surface reticulation—Material too cold. Filling rate too slow. Mold temperature too low.

Knit Lines—Caused by insufficient back pressure against the melt entering the cavity. Back pressure in the cavity can be increased by: fast injection against compressed air in the cavity, lower material temperature or reducing the thickness of the article. High mold temperature and high cavity pressure are also beneficial.★★

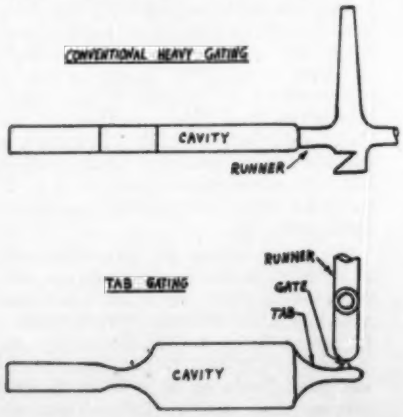


Figure 2. The Conventional Heavy Gate and the Tab Gate.

SPEaking . . .

(Continued from page 49)

extensions of the extruders and contain various types of gear like elements, transverse to the flow stream, driven by the extruder screw through suitable adaptors. Their use will generally provide substantial improvement in distribution and under some circumstances may even provide help in dispersion.

Dry colors and color concentrates do not produce extruded products of identical quality when given equivalent extrusion processing. The concentrates, wherein the pigment is predispersed by thorough shearing during manufacture, yield a higher quality dispersion in the end product. Dry colors, which are either not processed to break down pigment agglomerates or only partially so processed, are less satisfactory in this regard. Dry coloring may not yield the same color value as the concentrate route for equal pigment content for this reason.

Dispersion is generally a function of the state of the pigment prior to extrusion. Only under special circumstances can improvements in this parameter be obtained during the extrusion process. On the other hand, pigment distribution is primarily a function of extrusion processing, i.e., degree of mixing by the screw, a mixing head, regardless of pigment source.

The use of dry colors or concentrates depends on both quality and cost considerations. The dry colors tend to give poorer dispersions and usually involve a dusting problem, but they are relatively inexpensive. Color concentrates are preferred where quality governs but their cost reflects the additional service required to put the pigmentation in a desirable state. ★★

Needed—Book Reviewers

Books about plastics come out every month, and most of them are sent by the publishers to the SPE Journal for review.

If you'd like to write one or two reviews a year, we will send the books to you. The nice part is that the reviewer gets to keep the books he reviews!

When you write, let us know your field; type of plastics, whether chemistry or engineering, mathematics, molding, extrusion, general or the like.

SPE Journal, Security Bank Bldg., Athens, Ohio.

The Spanish plastics industry is described in a mimeographed publication of 33 pages, telling of the plastics organization, publications, manufacturers and the like. The "Boletin de Informacion" is available from Centro Espanol de Plasticos, Corcega 300, Barcelona, Spain.

MARLEX* 50 POLYETHYLENE Makes Tough, Colorful Rope

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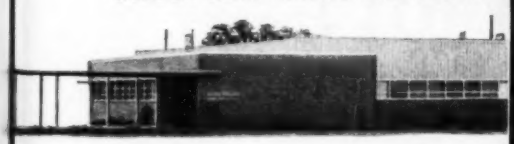
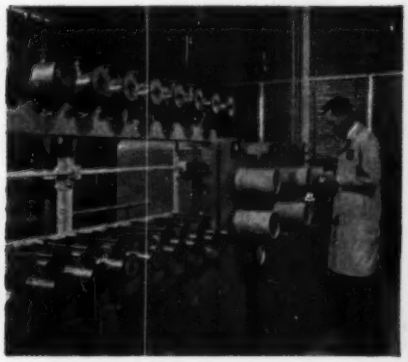


This new Sales Service Lab in Bartlesville is completely equipped with latest processing machinery and research apparatus. Phillips experienced technical service staff will assist you in developing new products and processes using MARLEX plastics. Please make arrangements through your MARLEX sales service representative.

Rope made from this revolutionary new polyethylene actually *floats . . . does not absorb water!* Thus, there is no swelling and consequent strand structure deformation when used in marine and other outdoor applications. Strength, endurance, heat resistance and light weight of MARLEX 50 rope will add to its popularity.



Filament spinning section at the Sales Service Lab, where MARLEX plastics specialists are constantly evaluating new manufacturing techniques and applications for MARLEX 50 filaments. They have discovered that filament elongation of this new plastic can be varied by orientation during processing from 5% to 30%, adding greatly to its versatility as a material.

*MARLEX is a trademark for the Phillips family of olefin polymers

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Action— By Your National Organization

"The objects of the Society shall be to promote in all lawful ways the Arts, Sciences, and Engineering Practices and Standards connected with the utilization of plastics."

Constitution and By-Laws

Your present National Constitution and By-Laws Committee has been working for over a year in an effort to accomplish several objectives in the rewriting of the Constitution and By-Laws. Some of these objectives are:

1. Bringing up to date all sections
2. Rewrite where necessary to cover work now being undertaken or to clarify situations that have arisen in recent years.
3. Clarify the intent and meaning where the intent is now obscure.

Any growing and expanding organization, such as the Society of Plastics Engineers, needs a good guide which clearly sets forth the goals, ideals and purposes of the organization. Our Constitution serves to keep the entire program of the Society in focus so that no one part is accented at the expense of some other part that may be equally important. Farsightedness of our founding fathers is certainly evident in the Constitution and By-Laws then written.

Divergent Opinions

One of the difficulties in editing or rewriting a vehicle such as our Constitution comes from the wide divergence of thought concerning just what it should be. One of our first committee tasks was to review all the minutes of the past several years and abstract from them any item that concerned in any way the Constitution or By-Laws. These items varied from ideas that were proposed and dropped, to entire sections which had been proposed for changes. Several Local Sections of the Society have submitted drafts of proposed revisions. These are all being considered as a part of the whole so that when the task is finished, it should not be necessary to spend valuable time at each National Council meeting discussing whether or not the "Rules of the Game" should be changed.

The "Open" Constitution

One group feels that the Constitution should be a rather open document which outlines the aims and purposes of the Society, and gives a general guide as to the handling and coordination of the various parts. This way of thinking would give the National Council and Local Sections a great deal of latitude in the actions which could be taken to accomplish any given objective. This group feels that "any course of action is permitted, provided the Constitution or By-Laws does not prohibit the action".

A different group feels that the Constitution should be the open framework of operation and that the By-Laws should spell out in great detail exactly what steps are to be taken and by whom, in order to accomplish our various objectives. This way of thinking means that we will have a rather voluminous document in which all phases of the operation are clearly and completely defined. This group says, in effect: "If the Constitution does not specifically provide for a certain action, then it cannot be undertaken without changing or modifying the Constitution".

The Moderate Outlook

It is the feeling of your present National Constitution and By-Laws Committee that in between these two extremes is probably the correct path to follow. However, the looser interpretation first mentioned seems to be the one that will make our future more certain and more easily obtainable. We are trying to develop the finished document into a general guide from which can proceed all the worthwhile things we, as a Society, wish to accomplish. The fact that the National Council has recently adopted all or parts of Procedure Manuals seems to point to the desire to make it easy to modify our procedures in line with the circumstances that present themselves from time to time.

January 1958 National Council Meeting is the time set for having as many of the important items completed as possible. Your committee is considering the many suggestions and is now in process of writing the finished drafts for presentation.

Arnold Varner

Wayne I. Pribble

Committee on
Constitution and By-Laws

Technical Committees Reports

Editor: Don Biklen

P.A.G. Organization

Plastics in Electrical Insulation

The proposed scope of the entire Professional Activities Group on Electrical Insulation is as follows:

1. There is a need in the plastics industry for an organization to obtain and disseminate knowledge in the special field of plastics used in electrical insulation.
2. There is a need in the electrical industry for more complete and reliable data on the processing and application of plastic insulation.
3. Since we are a group representing a plastics engineering society, we should concern ourselves primarily with organic plastics used in electrical insulation.
4. Electrical insulation is more often a composite of a number of materials rather than a single plastic. Therefore, knowledge should be made available on approved, composite plastic electrical insulation as well as on basic plastics.
5. We are not a testing group, therefore, we should collaborate with testing organizations to establish standard test methods. Only in those cases where other testing organizations are not interested should we establish specific standard test methods, should we so desire.
6. The main objectives of the P.A.G. on electrical insulations are: (these are also the objectives of each task group)
   a. To obtain more complete and reliable data on basic plastics and composite products based on plastics used as electrical insulation.
   b. To standardize our test methods on plastics and plastic products used as electrical insulation.
   c. To increase safety and decrease health hazards associated with the processing and use of electrical insulation.
   d. To disseminate information obtained in the above three categories and knowledge of general interest on electrical insulation through papers and publications.

P.A.G. Task Group on Fillers

Scope—The effect of Unoriented Fillers on the Properties of Encapsulating Resins.

This group proposes to arrange all existing data according to the following scheme:

I. Effect of Fillers on Electrical Properties
- A. Dielectric properties
- B. Insulation properties
- C. Arc resistance
- D. Moisture sensitivity

II. Effect of fillers on Mechanical Properties
- A. Tensile strength
- B. Compressive strength
- C. Flexual strength
- D. Impact strength
- E. Fatigue properties
- F. Creep properties

III. Effect of Fillers on Thermal Properties
- A. Thermal stability
- B. Thermal conductivity
- C. Thermal expansion

IV. Effect of Fillers on Chemical Properties
- A. Weight, volume and strength changes after immersion
- B. Stress-corrosion properties

V. Properties of Fillers, per se
- A. True density
- B. Coefficient of thermal expansion
- C. Coefficient of thermal conductivity
- D. Specific heat
- E. Hardness
- F. Size and shape of filler particle

VI. Methods of Mixing Fillers with Resins

VII. Effect of Precoated Fillers

It is thought that each entry should give the source, date of publication, and a brief description of the work. The group is starting on the business of abstracting the literature and putting the appropriate numbers in the appropriate cubbyholes under the above scheme. We will appreciate comments on the proposed scheme, as well as leads on sources of information.

(submitted by H. L. Parry)

P.A.G. Task Group on Crack Resistance

Scope—The first effort will be the establishment of standard test procedures. The present methods used at various labs will be evaluated for (1) reproducibility with a lab (2) reproducibility between labs (3) ease of use (4) cost of equipment (5) cost of running test and (6) correlation with manufacturing information.

(submitted by L. S. Buchoff)

P.A.G. Group on Hi-Temperature Encapsulating Resins

Scope—The specific objectives of the Hi-Temp Resin Group are

1. Determine the scope of encapsulating resins (should it include potting, casting and impregnating resins?)
2. Define "high-temperature" in relation to encapsulating resins.
3. Accumulate and classify available technical information.
4. Standardize and approve test methods
5. Determine (and encourage others to determine) unavailable essential technical data.
6. Disseminate technical information.
7. Propose (if we think it advantageous) a classification of Hi-Temperature encapsulating resins.

(submitted by Max M. Lee)

P.A.G. Group On New Methods of Producing Printed Circuits

Scope—The following is the scope for the SPE Task Group on New Methods of Producing Printed Circuits.

1) To study available methods of fabrication, including the reliability and economics of such processes, and descriptive features of printed circuits produced by these processes.
2) To consider applications needing improved methods or new characteristics or where existing methods fall short.
3) From a basic knowledge of printed circuit processes and materials as well as the knowledge of the properties of other processes and material to recommend revisions in fabrication which would tend to overcome shortcomings in method existing at present.

(submitted by P. E. Ritt)

Plastics in Building

An initial membership of 16 is selecting its general objectives, making a preliminary choice of areas for group work, and establishing an agenda for its first annual meeting in January at Detroit. This is being done currently by correspondence, but there may be a preliminary discussion and business meeting between now and mid-December. By the end of January, the group will have elected permanent officers, will be fully organized, and will be in full swing.

(submitted by Lucius Gilman)

Task Groups of the SPE Professional Activities Group on Plastics in Electrical Insulation

Group—Thermal Expansion and Crack Resistance of Encapsulating Compounds. Chairman—Mr. L. S. Buchoff, Electro-Tec Corporation, P.O. Box 667, Ormand Beach, Florida.

Group—Protective Coatings for Printed Circuitry. Chairman—Mr. E. L. Ditz, Melpar, Inc., 3000 Arlington Blvd., Falls Church, Virginia.

Group—Quality Control in Printed Circuit Materials and Processing. Chairman—Mr. W. A. Gammel, Sr., R-B-M Division Essex Wire Corporation, 131 Godfrey Street, Logansport, Indiana.

Group—Metering, Proportioning and Processing Methods for Encapsulation. Chairman—Mr. A. L. Kraft, Automatic Process Control, 1170 Morris Avenue, Union, New Jersey.

Group—Hi-Temperature Encapsulating Compounds. Chairman—Mr. M. M. Lee, General Electric Company, Specialty Motor Department, 1635 Broadway, Fort Wayne 2, Indiana.

Group—Dermatitis. Chairman—Mr. D. I. Nitzberg, Hoover Electronics Company, 3906 Liberty Heights Avenue, Baltimore 7, Maryland.

Group—Fillers. Chairman—Mr. H. L. Parry, Shell Chemical Corporation, Union, New Jersey.

Group—New Methods of Producing Printed Circuits. Chairman—Mr. P. E. Ritt, Melpar, Inc., 3000 Arlington Blvd., Falls Church, Virginia.

Group—Plated Thru Holes, Metallizing Plastics and Printed Components and Conductive Inks. Chairman—Mr. A. B. Rodriquez, Raytheon Manufacturing Company, Research Division, Seyon Building, Waltham, Massachusetts.

Group—Molding Compounds for Encapsulation. Chairman—Mr. M. Ross, Milton Ross Metals Company, Davisville Road, Davisville, Pennsylvania.

Group—Effect of Environment on Bond Strength Electrical Properties, and Adhesives. Chairman—Mr. G. P. Schmitt, St. Regis Paper Company, Panelyte Division, Enterprise Avenue, Trenton, New Jersey.

Group—New Polymers. Chairman—Mr. L. Spiwak, Rogers Corporation, Rogers, Connecticut.

Group—Chairman PAG. Chairman—Mr. D. I. Nitzberg, Hoover Electronics Company, 3906 Liberty Heights Avenue, Baltimore 7, Maryland.

Group—Vice Chairman PAG. Chairman—Mr. C. A. Harper, Materials & Process Engr. .052, Westinghouse Electric Corp., Air Arm Division, P.O. Box 746, Baltimore 3, Maryland.

Group—Secretary. Chairman—Mr. W. A. Gammel, Sr., R-B-M Division, Essex Wire Corporation, 131 Godfrey Street, Logansport, Indiana.

(above list submitted by Dan Nitzberg)

Classification of Task Groups

Group	Title		Examples	Applications
I	**Encapsulating Resins**			
	Casting	)		
	Potting	)	Polyester	Electronic companies
	Encapsulating	: Solventless	Polyurethane	Transformers
	Impregnating	)	Epoxy	Ballasts
	Plastisols	)	Silicone	Motors
II	**Varnishes & Coating Resins**			
Impregnating		)	Alkyd	
Ponding or Dipping		: Solutions	Phenolic	Coils
Enamels		)	Epoxy	Motors: Generators
			Formvar	Magnet wire
III	**Sheet & Film Insulation**			
	Film	) Thin	Mylar	Dielectric film for capacitors
	Tapes	: Flexible	Varnish cambric	Ground, layer insulation
	Impregnated Fabrics	)	Polyethylene	motors, transformers,
			Epoxy glass tape	Wrapping coils, cables
IV	**Laminates & Printed Circuits**			
			Phenolic-paper	Panels
	Laminates: Rigid		Epoxy-glass	Printed circuits
	Printed Circuit		Polyester-glass	Terminal board
			Silicone-glass	Washers
V	**Molded & Extruder Plastics**			
	Compression	) Hi-pressure	Nylon	Coil forms
	Injection	: Low-pressure	Polyethylene	Lead wire
	Extrusion	)	Silicone rubber	Spaghetti tubing: sleeving connectors

(above submitted by Max M. Lee)

"Progress Through Plastics Engineering"

The Fourteenth SPE Annual Technical Conference

Carl H. Whitlock

January 28-31, 1958

The Sheraton-Cadillac Hotel, Detroit

Have you ever wondered why some firms seem to get more than what you might consider to be their "share" of the market? Many obvious reasons might immediately come to mind but one important factor is virtually present in every case. That factor is: KEEPING PACE WITH THE INDUSTRY YOU SERVE. The company or individual that makes it a policy to be well informed on the latest developments in their industry and applies a progressive attitude towards these developments is best equipped to meet the demands of the market he serves. It is this type of firm that usually has a "backlog" of orders while other firms are wondering where the business went.

I can think of no more effective means of KEEPING PACE with the plastics industry than attendance at the S.P.E.'s forthcoming Annual Technical Conference (ANTEC). The 14th ANTEC will be held in Detroit from January 28 through January 31, 1958 with headquarters at the Sheraton-Cadillac Hotel. During these four days you will have no less than ONE HUNDRED AND TWO specialists on different phases of plastics on hand to report TO YOU on the latest technical developments in YOUR INDUSTRY.

Separate technical papers and moderated discussions will be presented in the following categories: Radiation & Plastics; Epoxy Resins and Embedment; Extrusion; Injection Molding; Packaging; Plastic Tooling; Mold Design; New Materials; Test Methods; Reinforced Plastics; Automotive Applications; Color and Finishing; Foams; Compression Molding; Sheet Forming and sessions on Education and Rheology. Here is a unique opportunity for you and your firm to KEEP PACE with your industry by taking advantage of the millions of dollars of research and development that went into the papers being presented at this conference.

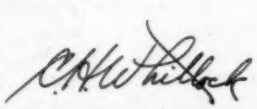
Another unique feature of this Conference is the fact that Detroit is the birthplace of our Society back in the early 1940's. The first Annual Technical Conference was held in Detroit back in 1944. Since that time the conference has met in various cities around the country and the attendance has grown from a hundred or so at the first meeting to over two thousand in recent years. Naturally Detroit, being the Mother City of the S.P.E., has been looking forward to this particular National Conference with a great deal of interest and enthusiasm. The 14th ANTEC Committees have gone all out in planning the finest conference that our membership and guests have ever attended.

One important indication of the enthusiasm is the overwhelming response received by the Speakers Committee on technical papers to be presented at the Conference. The quality and quantity of the papers submitted was such that the conference was extended an extra day and four concurrent sessions arranged in order to provide adequate coverage on every phase of the industry. There is no question that the 14th ANTEC will present one of the finest technical programs in the history of the Society.

In addition to Tuesday's annual business luncheon, we have arranged for a General Luncheon on Wednesday and will hear from one of the automotive industry's foremost engineers, Mr. Charles A. Chayne, Vice President of General Motors Corp., who will discuss "The Future of Plastics in the Automotive Industry". Thursday's banquet with a fine program will be preceded by a Cocktail Hour.

With this top-rate line-up of technical information and related activity the 14th ANTEC promises to be a record breaker in attendance as well. We cannot impress upon you too strongly the advantages of getting your advance registration in along with your hotel reservations for Monday, January 27th. This will allow you ample time to get settled in order to take full advantage of the program beginning on Tuesday morning with a general session on Radiation and Plastics, a subject you cannot afford to miss.

We, in Detroit, are proud to present this 14th ANTEC to you and are looking forward to your presence at the Conference. So . . . MAKE A DATE FOR '58! What's more important . . . MAKE IT NOW!



Carl H. Whitlock
General Chairman - 14th ANTEC

Abstracts of Conference Papers

Sessions Include the Following Topics . . .

Radiation and Plastics
Epoxy Resins and Embedments
Extrusion
Injection Molding
Education Symposium
Packaging
Plastics Tooling
Mold Design
New Materials
Test Methods
Rheology
Sheet Forming
Reinforced Plastics
Automotive Uses
Color and Finishing
Foams
Compression Molding

Tuesday, January 28, 1958 9:30 to 11:30 a.m.

Radiation and Plastics—I

Moderator—W. E. Gloor, Hercules Powder Company

Radioisotopes and Plastics by Dr. Paul C. Aebersold, U.S. Atomic Energy Commission

Radioisotopes provide research workers with a "kit" of extremely sensitive and versatile tracer atoms for research, development and process control in the plastics industry. As intense sources of radiation they have been used by engineers to catalyze reactions, produce cross linkage, degrade large molecules, and study radiation damage. Radioisotopes are being used for gaging thickness, determining density of coatings, and a multitude of other everyday uses. Radioisotopes from reactors have become plentiful at low cost.

The Role of Atomic Radiation in Plastics Science and Technology by R. F. Boyer and Robt. McFedries, The Dow Chemical Company

It is inevitable that the future role of radiation in plastics technology will be determined by its ability to compete with present techniques. The main factors involved in deciding this future revolve around:

1. Economics of radiation.
2. Advantages and disadvantages of radiation compared with conventional chemical methods.
3. Feasibility, in terms of available sources, radiation damage, shielding, uniformity of radiation dose, etc.

This paper presents a critical evaluation of such factors. The interaction of ionizing radiation with organic matter, probable cost and supplies of such radiation, and competitive methods are the basis for discussion of polymerization, cross-linking and graft copolymerization.

Accomplishments in Plastics Applications with Radiation —United States and Abroad by J. R. Stirrat, A. Miller, and E. Lawton, General Electric Company

This paper deals with commercially available irradiated plastic products, their properties and applications. Radiation chemistry of polyethylene is reviewed to provide a better understanding of the unique technical effects which have been achieved. Translation of technical effects into products designed to meet specific market requirements is covered along with the benefits resulting from the application of these products.

Tuesday, January 28, 1958 2:00 to 4:00 p.m.

Radiation and Plastics—II

Moderator—R. F. Boyer, The Dow Chemical Company

Ionizing Radiation by A. John Gale, High Voltage Engineering Corporation

Operation of a Radiation Facility by J. W. Ranftl, X-Ray Department, General Electric Company

Technical advances in the use of radiation to treat plastic materials and the development of irradiation equipment capable of handling production quantities of material have resulted in commercial application and the sale of irradiated plastic products. An increasing amount of future application in the industry is assured by the relatively low unit processing cost made possible by equipment available today.

The irradiation process, though certainly different from others such as extrusion and molding, is not complex and can be used with such processes in the fabrication of plastic materials.

The Irradiation of a Molded Article by R. G. Bauman, The B. F. Goodrich Company

Vulcanization or curing of molded rubber goods can be accomplished through the use of nuclear radiation. This technique avoids the use of all vulcanizing agents, accelerators, retarders, and heat. It provides finished rubber goods with aging properties superior to conventional cures.

In order to study the engineering practicability of radiation curing, a conventional 7.60-15 passenger car tire was radiation cured. This is the largest commercial item ever to be radiation processed to this date. This tire was successfully vulcanized using gamma radiation from twenty fuel elements from the Materials Testing Reactor at the National Reactor Testing Station at Arco, Idaho.

Graft Copolymerization on Polyethylene by H. G. Hammon, Battelle Memorial Institute

Graft copolymerization is a means of tailor-making a polymer molecule so as to incorporate desired properties. Preformed plastic materials, such as films, fibers, and thin sheet, may be modified by radiation-induced graft polymerization. A new type of X-ray tube provides a source of high-intensity radiation ideally suited for this purpose. The necessary equipment may be readily installed by most plastic fabricators due to minimal installation and shielding requirements.

Tuesday, January 28, 1958 2:00 to 4:00 p.m.

Epoxy Resins and Embedment

Moderator—C. A. Harper, Westinghouse Electric Corp.

Characteristics of Flexible Epoxy Resins by W. J. Belanger and H. C. Klassen, Jones-Dabney Co.

The object of this paper is to present physical and electrical property data on four systems capable of producing cured epoxide resins having a wide range of flexibility.

As the degree of flexibility of the cured epoxy resins was increased, the hardness of the cured resin decreased and the impact strength and thermal shock resistance increased accordingly. In general, the effect of increased flexibility is to decrease the electrical properties both at room temperature and elevated temperature.

Strain Gauge Evaluation of Casting Resins by R. N. Sampson and J. P. Lesnick, Westinghouse Electric

A new evaluation technique has been developed to investigate the effects of the factors which stress casting resins. The method employs a strain sensing element containing tiny wire-bonded laminates called strain gauges. Information has been obtained on the differences between rigid and flexible casting formulations, the effects of changes in the curing cycles. In addition, information can be obtained on the stresses caused by resin polymerization, and the effects of various fillers, hardeners, and resin combinations.

This test method yields quantitative results. The stress information obtained can be used to compare different potting compounds or to determine the results of a variation in composition in one particular compound.

Material Handling of Epoxy and Polyester Resins by W. A. Gammel, Sr., R-B-M Division, Essex Wire Corp.

Heat Resistant Epoxy Resin Systems by J. E. Carey and F. C. Hopper, Shell Chemical Corporation

A discussion of the strength and aging properties of a new, highly functional epoxy resin is presented. In laminates reinforced with 181 glass fabric, it retains 40,000 psi flexural strength at 500°F after 200 hours at this temperature. Its properties are compared to those of well-known commercial epoxy resins cured with several curing agents.

Tuesday, January 28, 1958 2:00 to 4:30 p.m.

Extrusion—I

Moderator—A. A. Kaufman, Prodex Corporation

Beta Gauge Measurement and Control of Plastic Thickness and Area Weight by G. L. Doering, Industrial Nucleonics

The increasing use of thin plastic film has emphasized the need for a more accurate measurement of weight per unit area. The extrusion—lamination process presents some unique measurement problems. The measurement requirements for blown bi-oriented films differ from those of the sheet die process.

This talk discusses the application of nucleonic equipment on the different extrusion processes.

Measurement accuracy can be 5 millionths of an inch in some applications.

The Effect of Relative Channel Depth and Curvature on Screw Extruder Pumping Capacity by P. H. Squires, E. I. du Pont de Nemours & Company

The basic theory of isothermal screw extrusion has in the past been presented in two forms: The two-dimensional or so-called "exact" theory in which the edge effects of the flight faces are taken into account, and the one-dimensional or so-called "simplified" theory in which these flight edge effects are neglected and which is therefore limited in application to screws of relatively shallow depth.

A method for presenting the two-dimensional theory has been developed wherein the resulting working equations are essentially as convenient and easy-to-use as those resulting from the one-dimensional theory. Application of the theory is extended to include partially empty screws (such as extractor screws).

Power and Heat Energy Relations in Polyethylene Extrusion by B. H. Maddock, Bakelite Company

Extrusion Theory by L. F. Street, Welding Engineers, and Hugh M. Hulburt and Dr. Stanley Katz of American Cyanamid Company

Tuesday, January 28, 1958 2:00 to 4:00 p.m.

Injection Molding—I

Moderator—Wm. J. Gobeille, American Motors Corp.

Injection Molding of Large Sections by M. Silovich, Evart Products Company

In the last five years injection molding has seen new concepts enter into the field of large section molding, mainly high speed injection, positive volumetric material displacement, and the hot runner with multiple gates.

These new techniques of molding are being employed by only a few molders because there are a limited number of large machines. Development of large panel molding techniques lagged because of the rapid growth of vacuum and other forming methods for uniform wall large panels.

Conical Heat Chamber by R. T. Wheeler, Crown Cork & Seal Company

A new style of heat chamber has been developed for use in injection molding presses. This chamber is conical, and has several advantages over standard heat chambers. It was designed primarily for molding rigid polyvinyl chloride. Having worked successfully for vinyl, it was used in molding polystyrene and polyethylene.

Drops in pressure need up to 37.2% were realized when molding rigid polyvinyl chloride, and up to 52.4% in molding polystyrene.

Preplastification for Injection Moulding by E. Gaspar and M. G. Munns, The Projectile & Engineering Company, England

This paper presents an analysis of the major process variables in injection molding and the effect that these variables have upon the quality of molded parts.

The inherent limitations in the single-stage orthodox injection molding machine which prevent a precise control of the variables being obtained are discussed.

Forming of Aerosol Containers of 'Zytel' Nylon Resin by J. B. Patton and R. M. Bonner, E. I. du Pont.

Tuesday, January 28, 1958 8:00 to 9:30 p.m

Education

Moderator—R. C. Bartlett, Natvar Corporation

Theme: SPONSORED RESEARCH IN PLASTICS

This will be a panel discussion on the following subjects:

Industrial View
Governmental View
University's View
Research Institute's View

Wednesday, January 29, 1958 9:00 to 11:30 a.m

Packaging

Moderator—Dr. M. J. deVietien, Paper Package Company

High Density Polyethylene Film for the Packaging Industry by L. F. Swec., W. R. Grace & Co.

Health Safety of Plastics Used in Food Packaging and Housewares by D. D. McCollister and W. J. Sauber, The Dow Chemical Company

In order to determine suitability for intended uses, a manufacturer must assure himself of sufficient knowledge of the chemical, physical and physiological properties of his product. Specifically, plastics for food packaging and housewares must be evaluated for safety from the public health aspect.

"Health Safety" may be defined as the practical certainty that no harm will result from a substance in a proposed quantity and manner of use. Two basic questions must be answered. In what amounts, if any, may the components of the plastic formulation occur in the packaged food? Is there a public health problem indicated by whatever amounts may be found?

Many plastic formulations have been studied sufficiently to be judged safe, or "suitable". Problems in promoting new products sometimes appear formidable.

End-Use Correlation of Styrene Container Testing by B. Nathanson, Monsanto Chemical Company

Within the past few years, the employment of styrene-type materials in containers has taken a firm foothold in the packaging industry. Many field quality problems have arisen, however, which previously had been solved by trial-and-error methods. Now testing methods are available which can better define and correlate the many end-use characteristics and empirical testing methods used in the field by the customer.

Correlation with shock impact at room and freezer temperatures for containers, correlation with flexing while empty (for drinking cups)—all of these, together with other criteria, can now be translated from empirical judgment to that of definitive grading by numbers.

Oriented Polystyrene Film by F. C. Dulmage, The Dow Chemical Company

This article briefly covers the history of the development of oriented polystyrene film.

Properties are compared with those of cellulose acetate and cellophane. Cost comparisons are also given on an area per dollar basis, showing its competitive position.

The effects of orientation on polystyrene film are described over a wide range. A graphic discussion dwells on the ideal orientation area with respect to a fixed set of conditions.

Wednesday, January 29, 1958 9:00 to 11:30 a.m.

Plastic Tooling

Moderator—F. Lyijynen, Chrysler Corporation

Plastics as Used for Tooling Aids in the Stamping Industry by E. Ruddiman, Ford Motor Company

This paper shares the experiences of the author in the use of thermosetting plastic materials in a modern stamping plant in the automotive field.

The author points out that the use of plastics in the construction of tools other than dies can win back the favor that may have been lost due early failures in plastic die building. While it may be true that these failures resulted from the misuse and misunderstanding of physical limitations of plastics, some managers have been inclined to reject these materials in any and all forms. That the field of plastic tooling is much broader than dies, is shown by reviewing the construction of such supplementary tooling as: models, spotting masters, development dies, checking fixtures and drilling fixtures.

Aircraft Tooling with Plastics by R. H. Voss, Warren Plastics and Engineering

1. Background
   (a) First use of plastic tooling in industry.
   (b) Current extensive use of plastic tooling.
2. Materials Advancements
   (a) Phenolics, (b) Polyesters, (c) High-heat epoxy
3. Tooling Applications
   (a) Mock ups
      1. Temporary, 2. Permanent
   (b) Fixtures
      1. Marking and drill templates.
   (c) Dies
      1. Stretch, 2. Drop hammer, 3. Draw dies
   4. Progress and accomplishments
      (a) Production dies, (b) Foreign countries and other industries applications of plastic tooling.

Plastics Application in the Foundry by W. R. Weaver, Modern Pattern & Plastics

Plastics for years have proven to be an intregal part of foundry operation particularly in sand binder applications. The advent of epoxy resins has now opened up a related field in foundry pattern applications. Heretofore patterns have been manufactured of wood and metal depending on production requirements. Plastic patterns are now proving adequate in small and medium production runs at a reduced cost to the foundry. Applications, advantages, disadvantages, and manufacturing techniques will be covered in some detail.

Plastics in the Metal Working Industry by G. M. Rice, Ren Plastics

Reaction to the word "plastics" is varied. To some, plastics means a magic universal material with practically no limitations—to others it is an inferior substitute for metal. Both extremes are widely prevalent, equally wrong, and the source of much of the industry's growing pains.

The outstanding advantage of plastics is that they can be cast or molded with inexpensive tools, and with a minimum of time and labor to close dimensional tolerances with little or no machining or spotting.

Reinforced plastics have made possible the development of new tools for the automotive, aircraft, appliance, and entire tooling industry.

Wednesday, January 29, 1958 9:00 to 11:30 a.m.

Mold Design—I

Moderator—L. J. Morrison, Detroit Mold Engineering

Machining Practices in Mold Making by E. J. Krabacher and P. A. Ropp, Cincinnati Milling Machine Company

Reducing Mold Costs and Improving Quality Through Planning Methods by Wm. D. Evans

Mold costs are one of the basic expenses of the plastics molding industries. These costs are principally expenditures for skilled labor. The utilization of skilled labor is a management problem susceptible to the application of engineering methods. This paper deals with proven engineering methods for the more effective use of skilled moldmakers.

The paper relates primarily to **how** molds are built. Improvement in quality by technical methods of precision, by reducing opportunities for errors through processing methods, and by providing a system of measuring dimensions for the machine operator to cut and for checking his work.

The Theory and Study of Proper Mold Design for High Density Polyethylene by A. Spaak, W. R. Grace & Co.

Due to the molecular structure of linear type polyethylene now being introduced on the market, it has become evident that proper mold design is important properly to mold a high quality complex commercial product. Linear polyethylene's sharp crystallization temperature, high degree of crystallinity and high viscosity has required well engineered mold design.

We will discuss the design of proper temperature control within the molds, the design of sprue, runners, and gate systems and discuss the necessity of high cubical displacement of the plastic material into a cavity when molding thin section parts.

This paper will show examples of laboratory work conducted which has improved warpage, shrinkage and flow conditions.

Mold Polishing by A. W. Logozzo, The Nutmeg Chrome Corporation

Wednesday, January 29, 1958 9:00 to 11:30 a.m.

New Materials—I

Moderator—E. L. Kropscott, The Dow Chemical Company

Practical Methods of Fabricating Articles from High Density Polyethylene Sheet by E. Rottner, Farbwerke Hoechst, Germany

Hot-air welding has been used with considerable success to fabricate structures made from rigid PVC. With high density polyethylene this method often results in weld strengths only 30% of the original material. This paper describes "butt-welding", a method of fabrication especially useful with high density polyethylene.

Two sheets of high density polyethylene can be joined by softening the edges of each sheet against a hot plate heated to 200°C., then pressing the sheets together causing the material to fuse along the seam. The joints are as strong as the base material.

Practically all welding problems which arise in the construction of apparatus and pipe of all types and shapes can be solved by these new welding methods.

Molding Characteristics of Diallyl Phthalate Compounds by L. B. Keller, W. R. McGlone, and D. H. Woodin, Hughes Aircraft Company

During the past few years a group of specialty thermosetting molding compounds based on diallyl phthalate resin have become available. These materials offer designers unusual combinations of properties, such as exceptionally high insulation resistance under high-humidity conditions, good dimensional stability and good mechanical strength. Because of their desirable properties these materials are widely used in the manufacture of electrical components for guided missiles and in other critical military applications.

This paper deals in a general way with the processing techniques, material characteristics, and normal problems which might be encountered during the compression or transfer molding of these specialty compounds. The different types of DAP materials commercially available are discussed in some detail; i.e., mineral-, synthetic-fiber-, asbestos-, and glass-fiber-loaded materials.

Lexan Polycarbonate Resin—A New High Strength, Heat Resistant Plastic by W. F. Christopher, General Electric Company

Lexan resin represents a new and novel family of aromatic polycarbonate resins. Resins in this family are generally characterized by: unusually high impact resistance, tensile strengths of 8,000-12,000 psi., melting points in the 200-300°C range, and good to excellent hydrolytic resistance, thermal stability and oxidation resistance.

Parts molded of Lexan resin show low water absorption, excellent dimensional stability, and good electrical properties.

Lexan molding resin can be molded in conventional injection presses, using existing molds and normal operating procedures. The material has a high melt viscosity and broad plastic range. Cylinder temperatures of 525°F to 600°F, heated molds, and injection pressures of 10,000 psi to 30,000 psi are typical for molding.

Application of Larson-Miller Correlation to Service Test Data on High Density Polyethylene by W. E. Gloor of Hercules Powder Company

Long-term pressure tests of pipe made from high-density (0.945) polyethylene at temperatures from 20° to 80°C. give curves of characteristic shape when time to fail is plotted against circumferential stress (or hoop stress) at failure. Measurements from 50° to 80°C. indicate a process of ductile failure governing for an initial period, followed by a period in which brittle failures are encountered. A well-defined knee or change of slope occurs between these regimes of failure in the plot of time to fail vs. hoop stress at any temperature. Using data observed for bottle failure of pipe at 50° and 80°C., the Larson-Miller correlation was applied to predict the course of these curves at lower temperatures, where polyethylene of density 0.945 is believed useful in pipe. This prediction is in accord with one obtained abroad using other methods of extrapolation.

Energies involved in the brittle failures of pipe are compared with those derived from data obtained from stress-cracking tests.

A permissible hoop stress of 670 p.s.i. at 23°F. (75°F.) was used to calculate wall thicknesses of pipe for long-time service made from high-density polyethylene of density 0.945.

Wednesday, January 29, 1958 2:00 to 4:30 p.m.

Test Methods

Moderator—F. W. Reinhart, National Bureau of Standards

Measuring Gas Transmission Performance of Plastic Packaging Material by W. E. Brown and W. J. Sauber, The Dow Chemical Company

The gas transmission of plastic films is particularly important in packaging foodstuffs. The choice of film relates directly to shelf-life. A non-permeable film is desirable for fat or oil containing foods to prevent oxidation and subsequent rancidity. Conversely, a high gas transmission rate is needed in fresh meat packaging to maintain its attractive bright red color. The same is true in packaging fresh vegetables which need to breathe to insure freshness.

The design of a new instrument has been adopted by ASTM Committee D-20 as the preferred method of D1434-56T (Tentative Method of Test for Gas Transmission of Plastic Sheeting).

The operation of the cell incorporates a method for clamping and supporting the film specimen, a glass manometer for collecting and measuring the pressure and volume of transmitted gas and a platinum wire in the manometer system for automatic recording. This instrument has been adapted to an 8 called automatic system now in operation.

Friction and Abrasion Characteristics of Plastic Materials by Mario Marcucci, Minneapolis-Honeywell Regulator

This paper describes the equipment used in studying the friction and abrasion characteristics of plastic materials, along with test procedures and results.

The equipment was so designed to be able to study the effect of 3 different sliding speeds simultaneously. These varied from 20 to 88 feet per minute. The normal force can be varied by simply changing weights. The tests were conducted with a normal force of approximately 4.5 pounds or by taking into account the area of contact of the riders, in the range of 250 to 300 psi.

A total of twelve materials were evaluated in this study including both thermoset and thermoplastic materials. The coefficient of friction was determined at intervals throughout the test period and the values plotted to study the differences between materials.

Applications of the Tensile Impact Test on Plastic Films by R. H. Carey and M. S. Nutkis, Bakelite Company

The tensile impact test, which is commonly applied to metals and solid plastics, can be applied with considerable success to plastic films. Neither the bag-drop test, nor the falling ball test which are currently being used to test impact resistance of films, are as simple to set up or apply as the tensile impact test. Because of the wide variations in values obtained for a film when using the falling ball test, investigations were initiated and the results revealed that the type of puncture made by the steel ball as it passed through the film has a great effect on the reliability of this test. The bag drop test makes no consideration of the thickness of the film. However, correlation can be made between the bag drop and tensile impact tests that prove they will test the same properties in a film.

Evaluation of Plastics for Compression Molding Phonograph Records by Use of a Capillary Extrusion Rheometer by W. E. Coleman, Monsanto Chemical Company

A method is outlined which was used to determine the important rheological parameters existing during the record molding process. This method is based upon empirical equations developed for the parallel-plate plastometer which is quite similar in operation to the record press. Motion pictures were taken of the press to record the rate of closing and the pressure build-up during the cycle. Data from the films were used to calculate the shear rate range during the cycles when using either vinyl or styrene phonograph record compounds. Test conditions on a capillary extrusion rheometer were based upon the above calculated range of shear rates. Using these conditions, an excellent correlation between record molding behavior and test data was obtained.

Wednesday, January 29, 1958 2:00 to 4:30 p.m.

Injection Molding—II

Moderator—M. G. Sherwood, Michigan Plastic Products

Effect of Processing Conditions Upon Specific Gravity of High Density Polyethylene by J. P. Fogerty and E. Poindexter, W. R. Grace & Co.

With most synthetic resins, it is possible to change the density of the material in injection molding through a variation of the processing variables. It is also possible to affect the density of highly crystalline materials by changing the degree of crystallinity. Such a study was performed on high density polyethylene.

Izod impact bars were injection molded of high density polyethylene and the variables of pressure, cycle time, cylinder temperature and mold temperature were varied through a wide range and independently. The samples were tested for density using the density gradient method. They were also annealed at various temperatures in an oxygen atmosphere and a nitrogen atmosphere and densities determined after cooling. As impact bars were used for the study, notched Izod Impact tests were also performed.

The density results showed that mold temperature resulted in the most significant changes in final density. It was also determined that annealing conditions had a very definite effect upon density. Impact strength was affected mainly by cylinder temperature.

New Techniques in Molding of Linear Polyethylene by D. A. Jones, Celanese Corporation of America

Better Operation with Better Plant Layout by D. B. Semeyn and R. L. Beesley, The Dow Chemical Company

Proper planning of the growth of a plant is necessary to assure smooth, economic operation, safety, and good working conditions for the employees.

The basic consideration in planning a layout of a manufacturing plant is the relationship with respect to material flow through the plant.

The plant should be laid out with this as the basic pattern so that material will be moved a minimum distance between departments, creating a minimum of aisle traffic and the least disturbance to other operations.

The shape of the main department, the molding room, is determined by the machine arrangement. Machines may be parallel, at 90 degrees, or at a lesser angle to the aisles. A large number of advantages are seen when machines are placed parallel to the aisle.

Molded Shrinkage and Dimensional Stability of Nylon 6 by J. M. Verdi and R. F. Flaherty, Barrett Division, Allied Chemical & Dye Corporation

Although nylon 6 (polycaprolactam) has been used extensively in Europe, it is a relatively new plastic nylon in the United States. Its excellent abrasion resistance, impact strength, and low coefficient of friction commend its use in many precision parts, such as gears and bearings, where close control of dimensions is critical.

Data are presented for simple solid shapes molded under a variety of conditions in order to provide an estimate of molding shrinkage of commercial parts. It is shown that shrinkage of Nylon 6 can be varied over fairly wide limits by varying molding conditions. Annealing will tend to minimize differences in mold shrinkage as a result of variations in molding conditions. Crystallization, which is dependent upon cooling rate, is an important factor affecting shrinkage. Control of mold temperature is an important tool for controlling the crystallization and shrinkage of thin section moldings.

Dimensional changes due to absorbed moisture and temperature fluctuations are also discussed. Proper procedures for estimating cavity sizes for precision parts are recommended.

Wednesday, January 29, 1958 2:00 to 4:30 p.m.

Reinforced Plastics

Moderator—M. J. Petretti, Camfield Fiberglass Plastics

Effects of Elevated Temperature and Erosion on Reinforced Plastic Laminates by N. B. Miller and E. L. Strauss, The Martin Company

This paper presents the results of a series of high temperature exposure tests conducted at the Martin Company. The purpose of this investigation was to evaluate the combined effects of high temperature and high velocity gas erosion on various structural plastic materials. The test setup and the results of the investigation will be illustrated by slides.

Test specimens were exposed to the afterburner blast of an Allison J-7 jet engine which produced temperatures of approximately 3000°F and gas velocities in the neighborhood of 2500 feet per second. The exposure time for the specimens ranged from 12 seconds to 60 seconds. The materials investigated included glass-phenolic, glass-silicone, glass-polyester and asbestos-phenolic laminates.

Development of Steam Resistant Fiberglass Reinforced Plastics by E. G. Bobalek, Wm. Ellslager, and T. Harris, Case Institute of Technology

Hospital utensils having a fiber-free surface finish and which can withstand autoclaving can be molded from fiberglass reinforced styrenepolyester resins by compression molding with matched metal dies of either resin saturated "preforms" or of "premix compounds." The principle requirements are:

1. Use of a hydrolysis resistance polyester. (Principally such as are based on aromatic-ether-polylols).
2. Exclusion of even trace quantities of water or heat sensitive materials from the molding composition.
3. Synthetic fiber overlays (e.g. steam resistant Dacron) or epoxy type coatings to promote a bright surface.
4. A release promoting finish of the die surfaces and careful attention to press operation and curing cycle.

Fabrication of Articles from Arcylic Sirup by J. A. Ross, Brian Mead, Jr., and J. T. Rundquist, E. I. du Pont de Nemours & Company

This paper describes the fabrication of articles from a new all-acrylic laminating resin, developed for producing weather resistant reinforced plastics.

The laminating resin, an acrylic sirup, can be used to make such glass reinforced products as corrugated sheet, flat decorative and structural sheet, furniture and other complex shapes. Structures made with this new resin have excellent resistance to weathering; thus the product is particularly useful in applications requiring outdoor exposure.

Most of the equipment now used by the industry for fabricating polyester resins can be used with acrylic sirup for production of articles by the contact process, press lamination with mat or preform, and press molding of premix compositions. Certain important process and equipment modifications are necessary however, and are discussed. In addition the effect of process variables on quality is discussed. Typical measurement and control methods are presented.

A Discussion of Polyester Premix by W. O. Erickson, Barrett Division, Allied Chemical & Dye Corporation

Wednesday, January 29, 1958 9:00 to 11:30 a.m.

Extrusion—II

Moderator—W. E. Jacobson, Yardley Plastics Company

Effect of Extrusion Conditions on Strength and Appearance of Polyethylene Pipe by J. F. Morris, Spencer Chemical Company

This paper is concerned with four conditions that can be controlled by the extruder. They are draw rate, stock temperatures, screw cooling, and reworking.

Although draw rate caused a difference in burst strength, it was not important in the 25 to 30% range of drawability.

The stock temperature in the 250 to 350°F range affected only the appearance. Pipe extruded below 290°F was not commercially acceptable.

Screw cooling had a real effect only on burst strength but it was not important from a practical point of view. Because of output reduction, it is considered best to use a neutral screw.

Reworking, as such, had no effect on burst strength or appearance of the pipe. Therefore, within the normal limitations of pipe processing equipment, a draw ratio of 25 to 30%, a stock temperature of 325°F, a neutral screw and virgin resin are recommended for processing polyethylene pipe of good strength and appearance.

Rigid Polyethylene Pipe by L. B. Croley and Robert Doyle, Phillips Chemical Company

Polyethylene Monofilaments by J. F. Groel and J. H. Versteeg, Bakelite Company

Polyethylenes for monofilament applications have received a substantial boost with the recent introduction of the low-pressure polyethylenes. Filaments extruded from these low-pressure polyethylenes are among the strongest of man-made fibers and in supplementing the present monofilament pacemakers should open the door to a vast number of monofilament applications. The paper reviews some of the important physical properties of polyethylene resins and compounds which make this material particularly desirable for many high-quality monofilament applications.

Sheet Extrusion and Vacuum Thermo Forming of High Density Polyethylenes by J. G. Farrow, Koppers Company, Inc.

Extrusion of higher density polyethylene sheet can be accomplished with equipment which is normally used for impact type styrene materials, but some technique modifications are necessary in order to produce a top quality product. These modified techniques principally center around the polish rolls and takeaway conditions. Likewise commercial vacuum thermo-forming equipment has been found to be fully adequate although modified procedures are necessary for higher density polyethylene sheet because of its higher heat resistance.

Thursday, January 30, 1958 9:30 to 11:30 a.m.

New Materials—II

Moderator—J. A. Clark, General American Transportation

Polyvinyl Chloride Pearls: Properties and Applications of a Unique Series of Resins by R. S. Holdsworth, W. M. Smith and J. T. Barr, Escambia Chemical Corp.

A new polyvinyl chloride resin, Pearl PVC, has been developed. This new polymer is characterized by exceptionally large particles which are uniform, porous and completely dust free. The plasticizer absorption of the PVC Pearl polymer is excellent and the resulting dry blends have good flow properties.

A series of high, medium and low molecular weight PVC Pearl resins were prepared. The processing, physical properties, color and clarity of suitable compounds based on these polymers are excellent.

The PVC Pearls are ideal for electrical applications. The plasticizer absorption, flow of the resin-plasticizer blend and the extrusion rates are good. The insulation resistance is acceptable and ages well. The use of PVC in rigid applications is growing rapidly. The PVC Pearl resin is recommended for uses in which good processing, high heat resistance and superior color and clarity are required.

European Progress in Plastics by Zoltan Merszei, Dow Chemical International Limited

There is in Europe the making of a single mass believe that European economic conditions will continue market consisting of about 370 mill. consumers. Many to improve to the point where the average individual will soon be enjoying a standard of living comparable to the one enjoyed at present by the American consumer. Should this prediction materialize, then the result will be a drastically increased activity in all segments of Europe's manufacturing, including its plastics industry. Such a development would conceivably bring about a situation where the plastics production of Europe would surpass that of the U.S.A.

Properties and Applications of the New Low Viscosity, Solventless, Thermosetting Silcone Resins by M. E. Nelson, Dow Corning Corporation

Two new solventless silicone resins were designated to form void-free encapsulations and impregnations for electric or electronic equipment. Full curing is obtained with peroxide catalyst and a step cure of nine hours at temperatures up to 390°F. Shelf life of the uncatalyzed resins is over a year, while pot life at room temperature of the catalyzed resins is over six months. Either of the resins may be used alone or with any of a wide range of inorganic fillers.

The low viscosity and fully reactive nature of the resins enable them thoroughly to saturate and penetrate the most complex assemblies and to convert to solid, bubble-free insulation. Cured, they exhibit excellent dielectric properties, moisture resistance, thermal conductivity and mechanical strength despite prolonged exposure to 400°F or intermittent service at as high as 500°F.

'Delrin' Acetal Resin—A New Thermoplastic. Properties, Fabrication and End-Use Testing by J. F. Cogdell and R. H. Hardesty, E. I. du Pont de Nemours & Company

A new thermoplastic has been created as the result of a fundamental research program of the du Pont Company. It is "Delrin"® acetal resin, a high melting, highly crystalline polymer which differs from other thermoplastics in chemical structure and physical properties. The building unit for this polymer is formaldehyde, a simple molecule with exceptional reactivity that has previously defied all attempts to polymerize it into anything but a low molecular weight solid having poor mechanical properties and low thermal stability.

This new stable superpolyoxymethylene with its combination of properties—stiffness, tensile strength, creep resistance, fatigue life, and low coefficient of friction, has the unusual feature of retaining a significant degree of its desirable properties, including dimensional stability under conditions of high temperature and humidity during an extended period of stress or during exposure to most solvents.

Thursday, January 30, 1958 9:30 to 11:30 a.m.

Automotive Applications

Moderator—J. T. O'Reilly, Ford Motor Company

General Review of Automotive Applications for Plastics by E. J. Storfer, Chrysler Corporation

Reinforced Plastics in the Automobile by J. G. Coffin, Chevrolet—St. Louis

Polyurethane Foam in the Automotive Industry by M. J. Sanger, The General Tire & Rubber Company

Engineers and scientists in industry have recognized the unique and valuable properties of these foams and are utilizing them in an ever-expanding number of applications.

Service data on polyurethane foam in cushioning is being accumulated as rapidly as possible. However, it is necessary to depend, to a great extent, on accelerated aging tests for indications of probable service life. A study has been made of the correlation of long term shelf aging test data with accelerated humidity aging tests. The good correlation found in this study is reassuring evidence that accelerated tests are valid indications of the quality of current polyurethane foams. Also, a comparison of an acceptable polyester foam with the newer polyether foam on a very severe accelerated humidity aging test shows the excellent hydrolytic stability of the polyether foam. The superior resistance of polyether foam to oxidative aging is also shown by results of a long oven aging test. An extensive accumulation of test data indicates that polyether foam can be expected to withstand any deteriorating influences encountered in service.

Plastics in Automotive Trim by R. McCullough, Ford Motor Company

Thursday, January 30, 1958 9:30 to 11:30 a.m.

Color and Finishing

Moderator—C. F. Massopust, General American Transportation Corporation

Coloring by the Molder by J. E. Simpson, Ferro Corporation

Recent Developments on Finishes and Application Techniques for Vacuum Metallizing Plastics by M. A. Self, Logo, Inc.

The process of vacuum deposited films is described along with a description of the types of coatings used in conjunction with vacuum metallizing of plastics.

A base coat is applied first and is the most critical part of the system. Some of the common problems include adhesion of the base coat to the substrate and the aluminum adhesion to the base coat. General film characteristics including build, tendency to orange peel or crater, and holding to corners also must be carefully controlled to obtain satisfactory parts. Iridescence, a term commonly applied to distortion of the plate caused by movement or swelling of the base coat is examined in detail. Loss of adhesion of the aluminum to the base coat on aging or in the humidity cabinet is common and is a subject of further study. Outgassing and humidity blush must also be taken into account.

Top coats and protective back-ups, although important for system integrity, are more similar to a normal finish and have fewer problems.

Hot Leaf Stamping by M. A. Olsen, Olsen-Mark Corp.

Two basic effects can be obtained by the hot leaf stamping process. One is the embossed effect where pigment or metallic colors are deposited by the use of a metal die, under heat and pressure, below the surface of the item being marked. The second is the top stamped effect where the color is deposited on top of a plastic surface raised from the body of the item. This top stamping is accomplished through the use of silicone rubber die material.

Hot stamping can be inexpensively and simply done if the following four components are obtained: 1. Stamping Equipment, 2. Roll leaf, 3. Die or dies, and 4. Supporting surface.

Some of the latest developments in the field of hot leaf stamping are:

Vacuum plated aluminum and dyed aluminum leaf which stamp with the appearance of chrome or gold plating; hard, lusterous, enamel-like finishes obtained by using luster roll leaf; and translucent stamping used on dials and knobs when the application calls for back lighting of a clear plastic piece.

Injection Molding of Dry Colored Marlex 50 Polyethylene by J. N. Scott, C. J. Silas and J. V. Smith, Phillips Chemical Company

Thursday, January 30, 1958 9:30 to 11:30 a.m.

Mold Design—II

Moderator—E. C. Fries, Auburn Plastics, Inc.

Mold Cost as Affected by New Metal Casting Methods by J. A. Kavanaugh, Standard Tool Company

Practical Design for Hot Runner Molds by J. R. Grenier, Protective Closures Co., Inc.

A practical, workable hot runner mold can be successfully designed for a broad range of application in polyethylene, polystyrene, butyrate and vinyl, when proper consideration is given to runner construction, temperature control and adequate cavity cooling.

The size and shape of the runners must be carefully engineered to assure even, simultaneous flow into the cavities.

The Use of Heat Resistant Epoxy Formulation for Producing Low Cost Molds for the Plastics Industry by R. T. O'Connor, Devcon Corporation

Epoxy resins were chosen by Devcon Corporation as the basis for a material to make low cost molds for plastics and rubber. A specially modified epoxy resin with a metallic filler was formulated and used with a combination of hardening agents to produce such a compound.

Preparation of the model, mixing the resin and hardener, and curing are the basic steps necessary to produce a cured epoxy casting, which can be used as a mold.

Tooling Cavities for Quality Class Commercial II Spur and Helical Plastic Molded Gears by J. R. Venne, International Business Machines Corporation

This paper discusses work carried-on by the Endicott IBM Plastics Laboratory in developing a simplified engineering method for obtaining dimensions for a gear cavity which will produce close-tolerance molded plastic gears. Methods selected for fabricating gear cavities, along with a tooling analysis for their selection, are described.

Plastic gears molded prior to the investigation were examined to determine the nature of shrinkage. This information was then compared with data currently available on plastic gear. The results of this investigation are presented in this paper.

Thursday, January 30, 1958 2:00 to 4:30 p.m.

Potpourri

Moderator—A. A. Pavlic, E. I. du Pont de Numours.

Publicity is NOT 'Free' by L. R. Grief, Grief-Associates.

Hoping to scuttle the popular misconception that publicity is just an unpaid substitute for advertising, Mr. Greif emphasizes that only the editorial space in a page or magazine is without charge. There are many incidental expenses involved and it will cost much time, intelligent planning, and, above all, much hard work.

After distinguishing between useful publicity and puffs, he will outline some proven methods of writing and illustrating press releases and feature articles. Clues on getting along with editors: "Be honest, on time, useful, and thoughtful."

Printed Wiring Processing by E. B. Murphy, Lincoln Laboratory, Massachusetts Institute of Technology

This paper consists of two parts; part I a colored movie (18 minutes) on the fundamentals of printed wiring processing as practiced at MIT Lincoln Laboratory. Part II covers specific developments and advances:

1. The principle, application, and potential of collimated actinic light to produce 3 D printed line products.

2. Printed wiring ferrite core memory plane processing problems and difficulties encountered in positive and negative processing.

3. Fine line etching as applied above, and also to stencils and grids of 5 to 10 mil lines and spacings.

Methods for Joining Plastic Parts by A. J. Cheney and W. E. Ebeling, E. I. du Pont de Nemours & Company

While familiar techniques as cementing and some welding techniques have been used frequently, the four methods discussed here are not as well known.

Chemically expanded rivets can be used with the more rigid plastics as nylon resin and at least with overlays of less rigid materials as polyethylene resin.

Press-fitting is one of the oldest and simplest fabricating techniques.

Induction welding is an exceptionally fast and versatile technique ideally suited for joining thermoplastics.

Spin welding is probably the most unique and least known method for welding thermoplastics.

Plastics Research and Development: Fact or Fancy from a Manager's Viewpoint by R. M. Houghton, Conap Co.

Thursday, January 30, 1958 2:00 to 4:30 p.m.

Extrusion—III

Moderator—C. N. Sprankle, Plax Corporation

Extrusion of Polyethylene Film with Controlled Properties by W. A. Haines and H. B. Robinson, Jr., Bakelite Company

Polyvinyl Chloride Dry Blend Extrusion in the Wire Coating Field by E. H. Hankey and R. D. Sackett, Monsanto Chemical Company

The extrusion of polyvinyl chloride dry blends has grown to a large volume because of economic advantages over granulated compounds. Similiar growth is probable in other areas now restricted to compounds if problems related to both materials and extrusion equipment are solved. Extensive research has been carried out to increase the knowledge of dry blend extrusion equipment design. The basic differences between PVC dry blend and granular compound with respect to extrusion behavior and screw design requirements are discussed.

Data are presented from a complete factorial experiment of fifty-four tests involving three different dry blends. These were extruded as wire insulation at three screw speeds with three different design short screws and three different long screws. The effects of screw design and extruder length on output, stock temperature, power input, insulation surface appearance, and porosity in the insulation are shown.

Nylon 6 Tubing—Extrusion Techniques and Effects of Environmental and Processing Conditions on Strength by J. L. O'Toole, H. G. Tinger, and T. R. von Toerne, Barrett Division, Allied Chemical & Dye Corporation

Nylon 6, like other engineering materials, is affected by environmental and processing conditions. Because of its higher melt viscosity when compared to older nylons used in this country, it is easily extruded with conventional equipment and simple tools. Laboratory tests show that by heating the quench medium into which it is extruded the strength of thin wall tubing can be improved. The strength of this tubing can be further increased by annealing.

Moisture content has a significant effect on the strength of nylon 6 tubing. Nylon 6 absorbs approximately 2.7 per cent moisture under average atmospheric conditions and absorbs up to 10 per cent moisture when immersed in water. The hoop strength of nylon 6 thin wall tubing varies from approximately 13,000 psi when "bone dry," down to 3,000 psi when saturated with water.

Teflon 100-X Perfluorocarbon Resin—A New, Melt-Extrudable Fluorocarbon Resin by R. S. Mallouk and W. B. Thompson, E. I. du Pont de Nemours & Co., Inc.

Property data are presented for a new, melt-extrudable fluorocarbon polymer, "Teflon" 100X perfluoro-carbon resin. These data show the new material to be similar to "Teflon" tetrafluoroethylene resin in electrical properties, chemical inertness, low permeability and excellent weather-ability. In addition, the polymer has superior thermal stability and maintains good physical properties at elevated temperatures. Techniques for melt extruding wire insulation, rod and tubing are discussed.

Thursday, January 30, 1958 2:00 to 4:30 p.m.

Injection Molding—III

Moderator—D. R. Fegley, Reed-Prentice Corporation

Maintenance Program for the Molding Industry by James C. Engman

Continuous processing requires a maintenance program of preventative and restorative segments accompanied by adequate record-keeping to reduce down-time, provide periodic pre-restorative investigations, establish diagnostic procedures, and extend personnel training.

Inventory requirements of replacement parts in variety and multiplicity can be reduced by in-plant repairs.

Process contamination hazards procry need for rigid house-keeping procedures and formalized follow-up pattern.

Variety and extension of equipment facilities indicate the need for personnel specialization and its procurement problems.

Wiring Diagrams—Their Purpose and How to Understand Them by F. R. Cinco, Reed-Prentice Corporation.

The paper attempts to explain a procedure which can be followed in breaking down the basic barrier between finding the solution through an analytical approach or floundering with a hit or miss method when trouble or faulty machine action occurs. Through an explanation of the standard device symbols, as established by various electrical committees, a better understanding of the two types of modern day diagrams will become more apparent. Interpreting the symbols into tangible components, examining what happens to these components, when placed in any circuity causes the meaning and comprehension to be self evident with proper association and comparison to a very basic analogy.

Automatic Injection Molding by Q. M. White, F. J. Stokes Corporation

This paper outlines briefly the economic reasons for the plastics industry continuing the search for new techniques in automatic injection molding. A history of past techniques will be discussed. A summary of the two present approaches to automatic injection molding will be presented. These two approaches are the use of conventional molding machines with automatic dies and secondly, automatic molding machines with standard dies. The discussion will include both machine design features and mold design features applicable to these two approaches.

Injection Molding by Automatic Means at Kodak Park Works by L. Ulmschneider, Eastman Kodak Company

Mold design, workplace arrangements, protective devices for molds, and systems for handling molding materials highlight the paper.

Thursday, January 30, 1958 2:00 to 4:30 p.m.

Foams

Moderator—R. H. Kittner, Mobay Chemical Company

New Developments in Vinyl Foam by H. E. Allen, Elastomer Chemical Corp., Unit of Union Carbide Corp.

Vinyl foam now challenges every other foam material in most commercial applications. Providing superior dimensional stability, resistance to moisture and oxidation, and full colorability, vinyl foam also provides certain unique properties that are not available in other flexible foams. It can be electronically heat sealed to fabrics, films, and other plastics by ordinary equipment. It can be given an exterior skin of vinyl film that is permanently fused to the foam itself. The abilities of the vinyls to be plasticized to various degrees of flexibility is shared by "Vinylfoam." A given weight foam can be very resilient, or soft and yielding, depending upon how much plasticizer is mixed with the resin.

Properties of Urethane Foams by J. H. Saunders, Mobay Chemical Company

Recent progress in the development of urethane foams is reviewed, with special emphasis on the improvements which have been made during the last year in the properties of flexible polyether urethane foams.

While the semi-rigid and rigid urethane foam fields have not moved so rapidly as the flexible foam, nevertheless, considerable improvements have been made in the last year and the mechanical equipment suitable for the processing of these foams.

Room Temperature Setting, Heat Resistant, Low Density, Silicone Foams by D. E. Weyer, Dow Corning

Four new silicone foams for lightweight, high-temperature thermal insulation will be introduced to the plastics industry. Two of the foams are liquid resinous compounds which, when catalyzed, will pour, expand and cure at room temperature to rigid or semi-rigid small-cell structures with densities in the range of 4 to 5 pounds per cubic foot.

Recent developments in silicone rubber foams include two compounds which can also be prepared at room temperature, but which will expand and "set" within as little as 4 minutes. Densities range from 5 to 13 pounds per cubic inch, with full resilience and flexibility being retained in service at temperatures ranging from -65 to over 500 F.

Epoxy Resin Foams by M. H. Nickerson, DeBell & Richardson, Inc.

Epoxy resin foams are a relatively new class of rigid, lightweight materials. Because they are thermoset by nature they possess excellent solvent resistance as well as the ability to stand elevated temperatures without slumping or melting. Their ability to remain rather tough and resilient at elevated temperature suggests some interesting uses involving post-forming of the prefoamed material.

Foam structures can be compressed and "frozen" in the compressed state. The compressed material can readily be expanded by heating to a temperature of 250 to 300°F, in which case it resumes its original shape and possesses most of its original physical properties; or, if desired, the compressed, or molded, shape can be fixed in its partially-compressed condition by coating it with a low-temperature-curing epoxy or polyester resin.

Friday, January 31, 1958 9:00 to 11:30 a.m.

Compression Molding

Moderator—S. H. Greenwood, F. J. Stokes Corporation

Compression and Transfer Molding of Epoxy Compounds by W. J. Dewar, Furane Plastics, Inc.

General discussion will cover the various types of epoxy resins and hardeners that have been used in the experimental molding and casting of epoxy compounds. The information will be presented relative to the newer complex type of epoxy molding compounds that are now being made available. Detailed information relative to curing conditions and ejection techniques will be covered as well as some of the problems peculiar to these low viscosity high flow materials. References will also be made to experimental data showing the effect of the various available epoxy resins on the properties of epoxy molding compounds such as heat distortion and flexural strength.

Automatic Preforming of High Impact Phenolic Materials by M. E. Lawrence, Logan Hydraulics Inc.

For many years the use of high impact phenolic molding materials such as types C.F.I. - 10, 20 and 30 has been very limited because of the high unit labor cost and consequent seemingly high price for the molded part.

A horizontal preforming machine that is hydraulically operated has recently been receiving the increasing attention of the molders because of its ability automatically to preform every type of phenolic material that is in general use today.

The automatic horizontal preformer that makes this high impact material cost saving possible is a development of major importance in the thermosetting plastic molding field.

Properties Required for Automatic Molding of Thermosetting Materials by F. J. Donohue, Monsanto Chemical

Properties required in thermosetting materials for successful automatic molding are:

1. Smooth uniform powder feed.
2. Rapid flow and fast cure.
3. Excellent mold and flash release.
4. Rigid set on discharge.

Rapid, uniform bulk powder preheating characteristics are also desirable in phenolic materials intended for automatic molding.

The Development and Application of Automatic Preheating of Thermosetting Powders by D. C. Amsler, Pass & Seymour, Inc.

To add automatic preheating to an automatic press requires working out the electrical interconnection between the press and the high frequency preheater so that they will operate as a unit. In addition, it is necessary to provide the appropriate mechanism and controls to meter the correct amount of powder for each cavity into a loading board having the same pattern as the cavities in the mold. A suitable drive must be provided to move the loading board into and out of the preheater. The materials used for the loading board must be capable of withstanding repeated cycles of preheating. The problem of stray radiation from the preheater must be overcome in order to keep within the levels permitted by the Federal Communications Commission.

We have also found that with preheating, the more uniform curing of the material increases the strength of the part 10-20% over that of a part molded from cold powder.

Friday, January 31, 1958 9:00 to 11:30 a.m.

Sheet Forming

Moderator—D. A. Davis, General Electric Company

Technical Aspects of Postformable Decorative Laminates by A. V. Dupuis, Monsanto Chemical Company

The postformable grade of decorative laminate is a relatively new segment of the plastic industry. It is a growing phase of the well-known countertop and furniture surfacing high-pressure decorative laminate industry and offers new features of beauty and serviceability.

The manufacture of this grade creates new problems for the decorative laminator. Monsanto Chemical Company has devoted considerable effort toward the development of materials and an understanding of the process variables

Using a newly developed test apparatus to supple-
for this product.
ment the standard NEMA test a study has been made of the effect of the major factors influencing formability.

Theoretical Aspects of Vacuum Forming Thermoplastic Materials by Leopold Dreifuss, Hydro-Chemie, Ltd., Switzerland

Extrusion and Thermoforming of Polyethylene Sheet by E. E. Griesser, A. L. Griff, and H. F. Tomfohrde, III, Bakelite Company

In this paper, the findings of a recent study on extrusion and thermoforming of polyethylene sheet are presented. This study covers all three ASTM types of polyethylene. The distinguishing properties and processing characteristics of each of these materials are discussed in detail. Also outlined are the pros and cons of using extrusion/thermoforming rather than other conventional fabricating methods.

The main part of the paper is devoted to technical field and from Bakelite Companys laboratories. In this recommendations, based on experience gathered from the section, recommended equipment and techniques, both in extruding polyethylene sheet and in thermoforming it into a quality end product are discussed and evaluated.

Advancements in Continuous Vacuum Forming Processes by M. J. Kalahar, Kal Plastics, Inc.

A review of the development of continuous vacuum forming of thermoplastic sheet from 1951 to the present day is the background for a description of the latest advances in machinery and technology in this field. Automatic vacuum forming and high speed trimming devices have increased the economic value of the production of disposable plastic packaging components. A cost estimate of capital requirements for the major machine units of a typical plant to extrude, vacuum form and trim disposable hot drink cups is presented.

Friday, January 31, 1958 9:00 to 11:30 a.m.

New Materials—III

Moderator—W. O. Bracken, Hercules Powder Company

Embrittlement of Polyethylene by C. S. Imig, Spencer Chemical Company

Among the strong attributes of higher density polyethylenes are their higher heat distortion temperatures than lower density polyethylenes. When being tried in high temperature applications, it was learned that these polyethylenes tended to embrittle after continued exposure to temperatures somewhat below the crystalline melting point.

A study of this heat embrittlement phenomenon showed that it was the result of two factors acting either jointly or independent of one another. The first was a growth of the crystallites resulting in an increase in density. Reworking samples which had been heat embrittled reduced the density so this change was considered only temporary. The second was polymer degradation through oxidation as seen by an increase in melt index and an increase in amount of carbonyl groups in the polymer after heat aging. In this case, reworking did not reduce the melt index so the change was considered permanent. The effect of antioxidants on heat embrittlement is now being studied.

There was no definite correlation found between heat embrittlement and density. Resistance to heat embrittlement was found to be better with lower melt index, higher molecular weight resins. In injection molding, higher stock temperatures were found to improve the resistance of a material to heat embrittlement.

Environmental Stress-Cracking of Polyethylene Injection Moldings—Practical Control and Test Methods by R. J. Anderson and S. R. Melvin, Monsanto Chemical Company

The general phenomenon of environmental stress-cracking in polyethylene injection moldings is discussed. Emphasis is placed upon molded polyethylene housewares and packaging, where this consideration is recognized as a serious problem.

The factors affecting such stress cracking are listed and described under environmental causes, material selection, additives, piece design and molding techniques. Presently popular industry tests are explained and analyzed with respect to injection molding. Development of specific item testing methods is outlined and several case histories are presented in terms of environmental factors and end-use requirements. Slides supplement the oral presentation.

Some Tensile Properties of Fractionated High Density Polyethylene by L. H. Tung, The Dow Chemical Co.

High density polyethylenes have been fractionated into narrower molecular weight distribution fractions. The stress and strain curves of these fractions have been determined. Yield strength, ultimate strength and total elongation were calculated from these stress and strain curves. The tensile modulus was determined by a special flexual method. In addition, the tensile impact strength was determined by the Bragaw method. These measurements were also made on several unfractionated low pressure polyethylenes of various molecular weights.

Early Detection of Weathering Damage in Polyethylene by J. W. Tamblyn, G. C. Newland, and M. T. Watson, Tennessee Eastman Company

Friday, January 31, 1958 9:00 to 11:30 a.m.

Rheology

Moderator—E. A. Haddad, Monsanto Chemical Company

Historical Introduction to the Rheology of Plastics by E. T. Severs, Natvar Corporation

Linear polyethylene of high density is being examined with great interest by the packaging industry in the

(Please turn to page 78)

Industrial Literature

Polyethylene Film

A new report entitled "Heat Seal Characteristics of Polyethylene Film" has just been published and made available to the Plastics and Packaging Industries by U.S. Industrial Chemicals Co., Division of National Distillers and Chemical Corporation.

The report was written in plain language and illustrated with 40 graphs to provide a useful tool for converters. The first half of the 16 page booklet discusses the prime conditions such as time, temperature, and the time and temperature ranges within which satisfactory heat seals can be made.

Copies of the report are available without charge to extruders, converters, and packagers from U.S. Industrial Chemical Co., Division of National Distillers and Chemicals Corporation, 99 Park Avenue, New York 16, New York.

Butadiene Manuals

Petro-Tex Chemical Corporation has issued what is claimed to be the first technical manual ever to be printed on Butadiene.

This 42-page book contains complete physical properties, polymerization data, chemical properties and detailed information on all principal Butadiene reactions. It includes a series of six "family trees" showing the chemical structure of present and potential products resulting from various classes of reactions and cites some 286 literature references.

Much of this data has hitherto been locked up in lab notebooks of the synthetic rubber program and is only now reduced to print by Petro-Tex. It should be very helpful to everyone interested in butane-based hydrocarbons, elastomers, fibers, plastics, coatings, etc., etc. A copy may be obtained without charge by addressing Petro-Tex Chemical Corporation, P.O. Box 2584, Houston 1, Texas.

Painting Recessed Areas

A leaflet describing various techniques used to fill recessed letters, symbols and numerals with paint has been published by Logo Inc. Division, Bee Chemical Company, Chicago 33, Illinois. It describes problems involved with using coatings and dry wipes on second surface clear plastics, as well as machine applications and different types of masks that can be used. The bulletin should be of interest to design engineers, process engineers and finishing room supervisors.

Electron Accelerator

Applied Radiation Corporation, Walnut Creek California, is offering for sale or lease to plastics fabricators, manufacturers and laboratories a high powered descendent of the atom smashers developed at Stanford by W. W. Hansen. The machine, a traveling wave linear electron accelerator, is designed for research in radiation chemistry and for limited commercial radiation processing. We have just published a complete brochure describing this accelerator, the Mark 1-F4, and would be happy to make it available to the readers of SPE Journal.

Inorganic Polymerization

PRINCIPLES OF INORGANIC POLYMERIZATION. A. B. Burg and others, University of Southern California for Wright Air Development Center, U.S. Air Force. May 1957. 68 pages. (Order PB 131180 from OTS, U.S. Department of Commerce, Washington 25, D.C., $1.75.) Researchers in this project continued to seek new patterns of chemical bonding and to consider their possible usefulness in relation to the invention of new polymers having unusual thermal stability. Some of the animo-phosphinoboron resins studied were found to be stable at temperatures approaching 500°C., and the limit is not yet known; however the problem of their poor mechanical properties remains. It was concluded that the phosphinoborine bonding principle withstands a great increase in the electronegativity of substituents on phosphorus. The stability of P-P bonding was found to be much enhanced by CF3 groups on P. so that the new compounds (PCF3)4 and (PCF3)5 are decidedly stable. Progress toward more electronegative substituents on boron is reported, and recently initiated work on phosphinoaluminum compounds produced some interesting materials.

Silicon Resins

DEVELOPMENT OF THERMALLY STABLE SILICON CONTAINING RESINS. L. W. Breed, F. Baiocchi, and H. W. Christie, Midwest Research Institute for Wright Air Development Center, U.S. Air Force. May 1957. 52 pages. (Order PB 131190 from OTS, U.S. Department of Commerce, Washington 25, D.C., $1.50.) This research was directed toward development of thermally stable silicon containing resins. Parts of the program already completed are described in full. The research includes the synthesis of silane monomers which contain two silicon atoms connected by arylene groups and have sufficient functionality to form a thermosetting polymer when hydrolyzed and cured. It also includes finding methods of hydrolyzing and polymerizing these monomers in which the maximum use is made of their functionality. Methods found suitable for synthesizing the monomers in quantities of one pound or more were used to prepare the following compounds: 1,4-bis (methyldiethoxysilyl) benzene, 4,4'-bis (methyldiethoxysilyl) phenylether, and phenyldichlorosilyl-trichlorosilylbenzene. Description of a statistically designed series of experiments to study the variables effective in the formation of laminates from silicone resins and glass fiber fabric is also included.

Polyvinyl Pyrolidone

A detailed, 48-page booklet on the versatile, high molecular weight polymer PVP(polyvinyl pyrolidone), describing its chemical and physical properties and the numerous applications so far developed, has been published by the Acetylene Chemicals Department of Antara Chemicals, a sales division of General Aniline and Film Corporation.

Copies may be obtained from Antara Chemicals, General Aniline and Film Corporation, 435 Hudson Street, N. Y. 14, N.Y.

Vinyl Acetate

A new 16-page booklet on NIACET vinyl acetate monomer has just been released by Union Carbide Chemicals Company, Division of Union Carbide Corporation. This booklet has sections on operating procedures, physical properties, specifications, shipping data, applications, polymerization techniques, analytical procedures, and physiological properties.

Heating and Cooling

American Hydrotherm Corporation, 10-55 Jackson Ave., Long Island City 1, New York, N.Y., is pleased to announce availability of a new publication, Bulletin 200. This bulletin offers pertinent information on high temperature heating and cooling systems for industrial process applications, and presents detailed information and curves on various thermal liquid heating media. Free copy is available on request.

NEWS of the industry

Award to Loma Plastics

Governor Price Daniel, in a special ceremony held at the Executive Mansion, Austin, Texas, today presented the annual "Boon to American Women Award" to Louis H. Barnett, president of Loma Plastics, Inc., of Fort Worth.

Barnett was cited in the scroll which accompanied the award for "A superior functional approach to the problems of the housewife" and "An imaginative and unconventional approach to the solution of increased home living problems" as displayed in his Loma plastic housewares.

Governor Daniel made the presentation on behalf of the Women's Research Guide, a non-profit organization of community-conscious women throughout the country, which selected the Texas manufacturer for the commendation after a survey of new developments in housewares highlighting new items that have proven most helpful to American homemakers.

Mrs. Katherine Hewell, of San Antonio and New York, president of the Guild, disclosed that Barnett's thriving plastics molding and designing operation had been chosen over other manufacturers largely on the strength of two new Loma products, a noiseless, unbreakable, 20-gallon trash can; and the firm's new plastic laundry hamper.

Governor Daniel spoke for the state of Texas in congratulating Barnett on the service award, and praised the youthful manufacturer-engineer, who has built Loma in less than a decade to a position of leadership in its industry.

Borden PVC Building

Completion of a modern, one-story office and laboratory building by its Polyvinyl Chloride Department in Leominster, Massachusetts, has been announced by the Chemical Division of the Borden Company.

The new facility will be operated in conjunction with the polyvinyl chloride resin plant opened by Borden's at the same location last year.

Recirculating System

A compact, self-contained, portable, cooling and recirculating SYSTEM (complete with air cooled compressor, recirculating pump and all necessary controls) has recently been developed by Mayer Refrigerating Engineers, Inc. of Lincoln Park, New Jersey.

Further information may be had by writing directly to — Mayer Refrigarating Engineers, Inc., Lincoln Park, New Jersey.

Winding Machine

A time-saving new machine which will unwind, accurately measure and rewind vinyl, poly and other soft plastics is now offered to the converting and cutting trade. This machine, manufactured by the Hobbs Manufacturing Company of Worcester, Massachusetts, well known for their line of plastic winding equipment, has several unique advantages. Details and prices on request from Hobbs Manufacturing Company, 26 Salisbury Street, Worcester, Massachusetts.

'Delrin' Plant

A large-scale plant to manufacture "Delrin" acetal resin, a new plastic material developed under Du Pont's fundamental research program, will be constructed near Parkersburg W. Va., the company announced today.

The manufacturing unit will be located at Du Pont's Washington Works on the West Virginia shore of the Ohio River where the company manufactures several other plastic materials. The plastic is expected to be in commercial production by mid-1959. Completion of the new unit will add 120 employees to the Washington Works operating force.

Necrology

William J. Dunnican

Mr. William J. Dunnican, of 352 Plymouth Road, Union, New Jersey, died following a short illness on October 21st. 1957. He was 54 years old.

Mr. Dunnican had spent almost 40 years in the plastics industry, starting in 1918 with Garfield Manufacturing Company, Garfield, New Jersey. He also held posts with Reilly Tar and Chemical Corporation in New York City and Indianapolis; Durite Plastics, Philadelphia; Synvar Corporation, Wilmington, Delaware; Gordon Chemical Company, Wilmington, Delaware; Sparta Industries, Sparta, New Jersey, and the Rainville Company, Long Island. His most recent work was as Sales Representative for Polyrez Corporation of Woodbury, New Jersey, and for Hull-Standard Corporation of Hatbora, Pennsylvania.

Mr. Dunnican was a member of the Plastics Pioneer Association, the Society of Plastics Engineers, Inc. (former National Vice-President). As the principal of Dunnican Associates, he was also a member of the Society of Plastics Industries, Inc. He was active in the B.P.O.E. and an active Mason.

Mr. Dunnican is survived by his wife and three married daughters.

Men In The News

Phillips Appointments

Several appointments have been made to the staff of the plastics sales division of Phillips Chemical Company, wholly owned subsidiary of Phillips Petroleum Company.

Named as sales engineers were A. R. Beckett, western district at Pasadena, Calif.; C. J. Silas, southern district at Bartlesville, Okla.; R. V. Porter and C. H. Luling III, Chicago district at Elmhurst, Ill.; L. A. Grundy, New England district at East Providence, R.I.; C. R. Loden, R. F. Lynch, and F. M. Jackson, New York, N.Y. district; A. C. Levinson, Akron, Ohio district; and F. C. Blue, division headquarters at Bartlesville.

The district offices serve plastics fabricators using the Phillips-developed Marlex thermoplastics in all areas of the United States, Canada, and foreign countries. George Wash is director and sales manager of the plastics sales division, and Walter R. Clark is assistant sales manager. R. Vernon Jones is manager of technical service and development.

Donald M. Ware

Donald M. Ware joins the staff of Fiber Glass Industries, Inc., of Amsterdam, New York.

Mr. Ware was previously associated with the Reinforced Plastics Division of Owens Corning Fiberglas Corporation.

Ernest J. Csaszar

The appointment of Ernest J. Csaszar to the post of Sales Engineer, Newark Die Company, was announced today by Islyn Thomas, President. The Newark firm is one of the country's largest manufacturers specializing in the design and production of molds for the plastics and die cast industries.

Mr. Csaszar has been a member of the Society of Plastics Engineers since its inception and at the present time is the Secretary-Treasurer of the Newark Section. He is also an active member of the Mold Making Section of the Society of the Plastics Industry, and the Chairman of its Policy Steering Committee.

Robert Lewis

TOY INDUSTRIES INC. announces the appointment of Mr. Robert Lewis to the position of Vice-President, in charge of plant production operations.

Mr. Lewis was previously in charge of production at Dart Plastics Co. in Brooklyn, New York.

AROUND THE WORLD

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UNITED STATES

JOURNAL OF APPLIED PHYSICS
October, 1957

Abstracter: J. C. Stansel

This issue is devoted mainly to plastics. There are eleven articles dealing with the subject and one or more should be of interest to persons concerned with design and application of plastics and in the field of polymer chemistry. Polyethelene and polystyrene receive most of the consideration.

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MATERIALS IN DESIGN ENGINEERING

September, 1957

Abstracter: Leonard Buchoff

Where to use Polyester Film — *Malcolm W. Riley*

This article discusses the properties and uses of polyethylene terephthalate film, marketed as "Mylar" by E. I. Du Pont de Nemours. Electrical, mechanical and decorative applications are described. Mylar's very high dielectric strength, high tensile strength, low permeability to organic solvents, heat resistance, and resistance to a variety of chemicals are shown in several tables.

A Guide to Synthetic Rubbers — *Malcolm W. Riley*

Properties of styrene-butadiene, butyl, nitrile, polysulfide, neoprene, silicone, acrylic, Hypalon and urethane rubbers and fluroelastomers are given.

This article is an excellent source of information in determining the rubber to use in a particular application. Tables of comparison between the materials as well as individual property charts facilitate the material choice.

The affects of fillers, additives and blending of different rubbers are described.

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RUBBER AGE

September, 1957

Abstracter: James Harrington

Elastomers for Use in Radiation Fields — *Robert Harrington*

The author describes the effects of gamma radiation on the physical properties of several elastomers and plastics. Elastomers which were irradiated while stressed in air degraded much more rapidly than when exposed to the same radiation dose and stress while in a vacuum. The stressed specimens in a vacuum had properties similar to unstressed specimens exposed to air during the same radiation exposure. Tests showed that marked differences in dose rate had no effect on the physical properties over a wide range of dosage levels.

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GERMANY

KUNSTSTOFFE

September, 1957

Abstracter: Anne Schwend

Plasticizer Effectiveness—a Function of the Structure of External Plasticizers — *F. Wuerstlin and H. Klein*

Di-electric measuring results serve as basis for a discussion of the external plastification of high molecular weight substances and the effectiveness of plasticizers. Previously published findings are confirmed. The internal mobility of a plasticizer molecule, characterized by its second order transition point, determines the order of plasticizers, and this independent from the substance to be plasticized. The temperature differences between the individual second order transition points of both high molecular materials and plasticizer determine the effectiveness of the plasticizer. Investigations prove that a certain substance acts as plasticizer if added according to the specific blending system, while in case of a negative temperature difference $t_p - t_w$ it will act as hardener.

Cross-linked Polystyrene for Electro-Technical Appliances — *W. Mertens and G. Kannebley*

Although interest in cross-linked polystyrene is growing in Germany, no such product of German origin has appeared on the market so far. Characteristics of cross-linked polystyrene imported from the U.S.A. are discussed.

Registering the Yield Point of Plastic Sheeting in Dependence of Temperature — *W. Voigt.*

Description of an apparatus permitting to register pneumatically a change in the modulus of elasticity of plastic films under minimum loads at rising temperatures.

Temperature-Resistant Glass Fibre Laminates — *Harro Hagen*

A review of U.S. and British literature as appeared on the subject of both thermal and mechanical capacities of a number of glass fibre laminates.

4th British Plastics Exhibition and Convention, London, July 1957

A resume of news and novelties made public at this year's British Plastics Exhibition and Convention, in particular low pressure polyethylene from British production, British-made polyterephthalic acid ester sheeting "Melinex" resembling Mylar films, synthetic mica and "Supramica" ceramic plastics for electronic apparatus withstanding continuous working temperatures of more than 500° C., butadiene and acrylonitrile co-polymers by British Geon Ltd.; the new Foster Yates low pressure injection molding machine with revolving table drew particular attention.

Combined Machines for Vacuum and Heat Forming — *Erich Escales*

The limits set for vacuum forming by a theoretical maximum forming pressure of 1 kg/sq.cm. made it imperative to look for other means to expand this method's application possibilities. It has been found in the use of the drop-forming method which permits a mechanical augmentation of the forming pressure. Practical realization of a combination of vacuum forming and drop forming was shown at the International Plastics Exhibition in London in July 1957 by Messrs. Hydrochemie of

Zurich. Their Formvac U-5 automatic thermoforming machine offers four different forming possibilities: a. straight vacuum forming; b. drop forming; c. Airslip forming; d. drape forming. The same company also offered another automatic machine for mass production of thermo-formed articles from both thickest plate and thinnest sheet materials. The "Formpack R-7" uses the drop-form method with negative mold and positive force plug and automatically clamps, heats, forms, chills, separates and ejects the stamped-out moldings via an electronic computer. Distribution of wall thickness is admirably uniform. A depth/diameter ratio of 2: 1 and more is achieved whereby walls may be drawn vertically or even undercut. Thus, this rotational automatic machine permits the fabrication of containers with horizontal struts and with threaded, spring or bayonet catches. The machine works on a multi-step rotational principle for continuous thermo-forming with heating for sheet material on both sides and stepless temperature control.

High-Polymer Research in Both Moscow and Leningrad

Excerpt from a report by the Polish-physico-chemist E. Turska on her studies of the centres of high polymer research in the USSR. Research problems and methods resemble those in Western Europe and the United States.

Bonding of Polystyrene Parts—Precautions in the Use of Toxic Solvents — *H. Sontag*

Maximum concentrations of gases, vapors or dusts of toxic character stipulated first in the U.S. as admissible for workshops in which polystyrene parts are bonded and assembled, have also been adopted in Germany. Inherent regulations are interpreted.

Thermoplastic Machine Parts — *H. R. Jacobi*

A review of thermoplastic materials and their properties making them suited for a number of machine parts such as nuts and screws, absorbers, toothed wheels, gears, friction bearings, driving and conveyor belts, containers, casings, handles, switches, slides, packings, valves, etc. Basic principles and factors to be observed upon use of thermoplastics for machine parts are discussed.

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KUNSTSTOFF-RUNDSCHAU

September, 1957

Abstracter: Leo Fischer

Four Interesting Synthetics of Today — *E. Wanderberg*

This article discusses the four newest synthetics—silicones, epoxies, polyesters and polyethylenes. These resins are based on the following principles: when the molecular structure of resins is linear a thermoplastic results. If a lattice formation exists the resin is thermosetting. Lattice formation follows three directions; condensation with the splitting off of molecules and the formation of water; polymerization, which requires no pressure; addition polymerization, a combining of molecules but resulting in no splitting and no formation of water. A combination of two principles produces polyesters.

The article in a routine manner discusses the four resins mentioned and gives their uses and applications.

Synthetics Help Rationalization — *Reinhard Walter*

The author defines "rationalization" as an economic force to raise the standard of life. For this it is basically necessary to increase the economic production per worker in industry, to improve the products themselves, to make them more durable, and to create new products for better living. Plastics play a very important role in this sphere. The article stresses in great detail that the value of plastics is not in substitutions or cheaper products, but in creating new uses, new durability, new appearances and new comforts. He lists a great many applications of plastics where their use has made considerable contributions to the improvement of our economy. Many improved products and new products are discussed. It is especially interesting to note how many spheres of entirely new economic activities have been created as a result of the advent of plastics.

Suggestions for Fabricating Hard PVC and Other Thermo Plastics — *H. Jungnickel*

Although plastics have many excellent and often unbeatable qualities many an application is inferior because of poor workmanship. A recurrent problem is the joining of sheeting and pipes. The article illustrates a number of good and bad techniques. The author prefers adhesives to welding especially in joining of pipes. Of course where sections are fabricated from flat sheets welding may be necessary and he stresses that the welds must be in the proper location to be effective. Corner welds should be avoided wherever possible. Where PVC is laminated to wood or metal adhesives with solvents are not recommended. Dispersions with water evaporating before the parts are put together are preferred. Many other suggestions for proper fabrication are given.

August, 1957

The Influence of Chemical Structure on Double Refraction of Macromolecular Substances — *J. Majer and J. Dvorak*

Isotropic high molecular materials are able to form a double refraction through external tensions, usually pressure. The optical tensile constant of the double refraction will always be a linear function of the modulus of elasticity. The greatest optical refractive sensitivity is obtained by the aromatics, especially the saturated polymers. The double refraction, influenced by the tensile factor, also represents a function of the modulus of rupture. With a rise in the index of the modulus of rupture the refraction constant gets lower. The optical constant is also a factor in determining expansion and contraction characteristics.

The calculated values of the refraction constant are usually somewhat smaller than the empirical measured values. Although the theoretical equations do not fully suffice to determine the physical characteristics of the macromolecular substances, they are of some value.

Styrenated Oils and Alkyds — *M. Bottcher*

This concluding article on oils and resins for the paint industry describes the patent literature extant regarding the styrolization of oils and alkyds. Most of these patents deal with copolymerization of styrene monomers and the various resins used in the paint industry.

Swedish Plastics Society Meeting

The proceedings of the Tenth Anniversary Celebration of the Swedish Plastics Society are described. Numerous papers are abstracted dealing mostly with practical production problems in the plastics industry of Sweden.

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DER PLASTVERARBEITER

August, 1957

Abstracter: Leo Fischer

Development and Application of Synthetics in the Building Trades — *R. Walter and D. I. Frenz*

Total German industry has grown 200% since 1936, the plastic industry 564.% PVC represents 30% of this growth. This is chiefly due to the use of PVC in construction. An important factor in the widespread use of PVC for flooring and walls is not only their beautiful appearance and excellent physical characteristics, but the lack of service personnel for cleaning and maintenance. Another, newer application is window-sills and frames, usually as coatings on rigid construction materials. Another wide application is polyvinyl acetate for producing floors by the troweling method.

Piping and tubing is also widely used. Polyethylene piping is especially in big demand to prevent freezing weather from bursting water filled pipes. The use of glass fiber reinforced sheeting for roofing is becoming widespread. Melamine and phenolic decorative laminates are only lately gaining acceptance.

Vacuum and Air Pressure as Aids in Injection Molding — *Heinrich Spies*

The difficulties in molding a long article that usually presents problem of air entrapment is discussed here. Merely venting the piece does not produce uniformly good results. The author suggests the use of a fine cut in the plunger or male part in order to let the air out as the mold closes.

When the mold is closed a vacuum is applied. This takes out the remaining air and also helps to cool the piece thus preventing burns. The article is well illustrated.

Methods of Forming Acrylic Sheets— *Heinz Greiner*

The difficulty encountered in forming acrylic sheets is the retention of optical clarity. The roughness of an acrylic sheet is measured around 0.03 to 0.06 microns obtained with an interference microscope. Another problem is, of course, the uneven thickness developed during forming and thus distorting the optical clarity and affecting the strength. If the degree of refraction is 5° or over the clarity is disturbed. It is suggested to avoid the use of metal in forming tools but rather to use compressed wood fiber boards, casting resins or cement compositions.

The author establishes a method to compute the practical shape for forming whereby the least optical distortion and variation in thickness takes place. There is a depth to width to volume relationship expressed in an equation. A factor involving the total surface area is also taken into account. This article has some useful suggestions in designing objects for press forming acrylics.

A Polyester House for Five People— *Hugo Brendel*

The house described in this article is built of polyester glass fiber structural units. Ceramic pipes are cast into the structural members. Prefabricated sections are assembled on the job. No metal framework or steel trusses or beams are used. The general design seems somewhat conventional in comparison with the American "Plastic House" but it is much lower in cost and seems quite efficient.

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GREAT BRITAIN

BRITISH PLASTICS

August, 1957

Abstracter: Evert A. Mol

Report on the 4th British Plastics Exhibition and Convention — *Staff Written*

The August issue of British Plastics has been devoted completely to the 4th British Plastics Exhibition and Convention held July 10-20 in London. Generally, it can be said that there were no startling developments in materials but quite an intensive development of improved machinery. The machinery section was quite international in that 29 overseas companies brought machines or equipment to London. The convention was also international in character; of the 18 papers presented, five were from the United States and three from Germany. The following papers were presented:

"Synthesis and properties of olefin and diene polymers," Dr. H. F. Mark, Polymer Research Institute, Brooklyn, U.S.A.

"Some aspects of low-pressure polythenes," Dr. Erhard Grams, Farbwerke Hoechst A. G., Frankfurt, Germany.

"Light scattering of polythene in solution," S. W. Hawkins, P. B. McFarlane and F. Yearsley, Alkali Division, Imperial Chemical Industries Limited.

"The effect of crystallinity on the permeability of polythene to gases and vapours," C. E. Rogers, A. W. Myers, V. T. Stannett and M. Szwarc, State University College of Forestry, Syracuse University, New York.

"Factors influencing long term stress properties of polythenes", James A. Reid, J. E. Pritchard, and W. B. Reynolds, Phillips Petroleum Co., Bartlesville, Oklahoma.

"The physical properties of lightly plasticized p.v.c. compounds," R. A. Horsley, BX Plastics Research Station, Manningtree.

"Foamed polyvinyl chloride," Denis A. Lever and G. Burke, British Geon Limited.

"High impact rigid vinyl materials," By Clarence Parks and G. B. Jennings of the B. F. Goodrich Chemical Company, Cleveland, Ohio.

"Some aspects of high density polythene pipes," Dr. Hermann Paul, Chemische Werke Huls, Recklinghausen, Germany.

"Some recent developments in extrusion," Alexander Kennaway, Imperial Chemical Industries Ltd. Plastics Division.

"Developments of extrusion in Germany," Dr. Gerhard P. M. Schenkel, Paul Troester Maschinenfabrik, Hanover, Germany.

"The influence of preplasticization on the injection moulding process," E. Gaspar and M. G. Munns, Projectile & Engineering Co., Ltd.

"The significance of injection rate in moulding," L. W. Meyer and L. E. Tallman, Dow Chemical Company, Midland, Michigan, U.S.A.

"A study of injection moulding of toughened polystyrene," G. Hulse and Dr. A. Z. Borucka, Monsanto Chemicals, Limited.

"Recent developments in fluorine polymers," G. W. Bowley, Plastics Division, Imperial Chemical Industries, Limited.

"Recent developments in arc resistant thermosetting materials," Dr. J. Hofton and C. P. Vale, British Plastics, Ltd.

"Relative merits of epoxide, phenolic and polyester resins in glass reinforced plastics," L. H. Vaughan, Bakelite, Limited.

"Reinforced plastics for efficient structures," W. Andrew Baker, Bristol Aircraft, Ltd.

Separate, well-illustrated sections are devoted to the most important plastics like acrylics, amino plastics, cellulosics, fluorine plastics, nylons, phenolics, polystyrenes, polyethylenes, vinyls and reinforced plastics.

The section on machinery is highly interesting in that it describes and shows a great many foreign machines that are very seldom mentioned or described in American literature as, for instance, the Italian Triulzi injection molding machine, the French Andouart extruder, and the Belgium Mapri twin screw extruder. Most of the German machines have already been described in some detail in the June, 1957 issue of British Plastics.

July, 1957

Fillers for P. V. C. — *I. Phillips and P. G. Youde*

The theory of filling of P. V. C. is basically different from that for rubber. The authors list the basic requirements for a P.V.C. filler and then proceed to a short description of the types of fillers in common use. The methods for assessing fillers in pastes and compounds are interesting. The properties of flexible compounds with various fillers at various concentrations are discussed and described with the help of a large number of graphs. Among the properties discussed are specific gravity, the volume resistivity, water absorption, cold flex temperature, and softness. It is shown, for instance, that lightly calcined china clays can improve the volume resistivity by as much as 10 times without increasing the water absorption to a measurable degree. Stearate-coated natural ground whiting of fine particle size can be incorporated in considerable loads before unduly affecting hardness, strength and cold flex. This means that in many cases substantial savings can be realized when using this whiting as a filler.

An Introduction to Thin Wall Moulding — *M. P. Brown and E. Gaspar*

This article is largely a description of a Peco injection molding machine that utilizes the principles for thin wall molding developed by the author. Some of their conclusions are pretty obvious as, for instance, that there is a limit to the size of the thin wall container that can be produced by injection molding and

that easy flow materials can be of great assistance. On the whole, however, the article is very informative and a good example of how basic considerations can be turned to good use in mold and machine design.

June, 1957

Developments in Reinforced Plastics — *Staff Written*

This article is a collection of abstracts of papers presented at the technical conference on reinforced plastics held by the British Plastics Federation in Harrogate on May 1, 2 and 3, 1957. Because it is very difficult to abstract abstracts, we will just list the titles of the papers which together comprise a worthwhile and diversified review of the latest techniques in the reinforced plastics field.

"Competitive routes in the thermal decomposition of polyester systems," by P. D. Ritchie.

"Some aspects of the development of heat resistant laminates and laminating resins," by D. B. V. Parker, E. W. Russell and W. W. Wright.

"An investigation of chemical finishes for glass fabrics used in the manufacture of reinforced plastics," by A. de Dani and J. Nolan.

"The effect of heat on the flexural strength of certain glass fabric filled laminates," by W. J. Read.

"Raw materials for polyester resins," by Brian Parkyn.

"New developments and potentialities of asbestos-based plastics," by G. S. Learmonth.

"The matched metal die moulding of chopped glass fibres and polyester resins," by C. Joseph.

"Injection moulding of reinforced plastics," by J. Rees.

"Moulding glass fibre (doughs and allied materials)" by M. Lewin.

"Autoclave mouldings," by H. P. Martin.

"The latest methods of hand lay-up moulding," by F. Boydon.

"The inspection of polyester/glass structures," by Dr. J. H. Martin.

"The fatigue and creep properties of plastic laminates," by A. W. Thompson.

"Reinforced plastic pressure vessels," by A. Wilson.

"Some results with the application of glass fibre-reinforced plastics in aircraft construction," by Rob J. Schliekelmann.

"Medical aspects of reinforced plastics manufacture," by Dr. E. E. Lieber.

Some Recent Developments in German Processing Equipment — *Staff Written*

This is a very informative article for people who want to acquaint themselves with recent developments in Germany. They will find that the German plastics processing equipment is at least at the same technical level as here in the United States and, the abstracter thinks, even ahead in some cases.

The German extrusion machine builders, for instance, have paid considerable attention to adiabatic extrusion and various constructions utilizing this principle have been worked out. For instance, a company called Alpine AG has come out with a laboratory extruder that operates fully adiabatic. Barrel heating and cooling have been fully eliminated except for a short, electrical preheating of the die head. The process is simply controlled by a throttle at the output end of the screw. The builders claim that it is suitable for processing P.V.C., all types of polyethylenes, polyesters, cellulose, acetates, acrylics, polystyrenes, and polyamides.

Also described is new or improved equipment made by well-known companies such as: Johann Fischer Abt Maschinenbau, Paul Troester Maschinenfabrik, Ruth Schwabenthan Maschinenfabrik, Herman Berstorff Maschinenbau, J. Kleinewefers Sohne, Hoepfner GmbH, and Reifenhauser Maschinenfabrik, et al. A cut-away of the Reifenhauser 150S gives an idea of the sturdy construction and reliable drive of this machine. Most machine manufacturers have paid considerable attention to accurate temperature control. Quite a few claim control accuracy of the order of ± 1°C. Generally the trend is to very high length over diameter ratios. Kleinewefers goes as high as 24:1.

In the injection molding field, increased use is being made of screw type pre-plasticizing units. Interesting specialties like bottle blowing machines, swivel nozzles, and vertical injection molding have been reported. Automatic and semi-automatic auxiliary equipment like granulators and mixers, vacuum forming machines, foam handling equipment and radio frequency welders are available in many types.

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TRANSACTIONS & JOURNAL OF THE PLASTICS INSTITUTE

July, 1957

Abstracter: H. H. Dash

Plastics in Boats — *H. A. Collinson*

The use of plastic materials is discussed for both small craft and large ships. The paper also covers the more recent use of reinforced plastics in boat construction.

Plastics have found their way into boats primarily because of their superior resistance to salt water over that of metals and wood. In small craft, fittings (blocks, cleats, reefing gear, etc.) made from fabric based phenolics have found extensive use. For construction purposes, the resin glues, particularly those compounded from resorcinol-formaldehyde resins, have found strong favor. The use of these glues has permitted plank lamination of superior qualities than heretofore possible for yacht construction. They have also eliminated the need for maintenance and caulking.

Plastics are also employed in navigation instruments (phenolics, vinyls, acrylics), sails and cordage (nylon, terylene), flooring (PVC), etc. The employment of plastics in large ships has been mostly confined to fittings, furniture, flooring, and other miscellaneous use. Glass reinforced plastics bids fair to challenge wood as the basic construction material for boats of varying sizes. This is accounted for on the basis of several superior properties of the reinforced plastics. Both single and matched mold techniques are employed in boat construction.

Thermoplastics in the Submarine Cable Industry — *Sir John Dean*

Prior to World War II, rubber (gutta-percha and balata) or modifications of same (Paragutta, K-gutta) had been the standard extruded covering for cables. However, at higher frequencies, these rubbers show too great a dielectric loss. It was not until the development of polyethylene just prior to the war that made possible the production of efficient high frequency co-ax cable. The later use of corrosion and abrasive resistant polyvinyl chloride sheathing considerably improved the production of armour wires for submarine cable. Expanded polyethylene currently represents one of the more significant developments in dielectric materials for cable use.

The Industrial Application of "Terylene" Polyester Fibre — *J. R. A. Kennedy*

Terylene is IC I's trade name for the terephthalate polyester fibre produced from ethylene glycol and terepthalic acid. It was developed in 1940 and is currently being produced at an annual output of 22 million pounds. Equivalent fibres produced in other countries are Dacron (US), Tergal (France) Terlenca (Holland), Terital (Italy), Trevera and Diolen (Germany).

Reaction and process flow charts are presented with the paper. Filament yarn and staple fibres with strengths 3 to 6 times that of wool are produced by a melt spinning process. The chemical and physical properties of Terylene are discussed in detail. Industrial applications include conveyor belting, V-belts, hoses, tire cord, fabrics, laminates, cordage, etc. Many extended uses are predicted for the future.

SECTION NEWS

Edited by
David Mersey
190 Camden Road
Hamden, Connecticut

Chicago

Transfer and Injection Molding of PVC

Joseph J. Schmidt

The October meeting of the Chicago chapter of the SPE was held at the Western Society of Engineers, October 14th at 7:30 p.m.

The meeting was called to order by president Ken Rouzer. Ken spoke about the National Directors duties and the fine job Ken Gossett was doing in fulfilling this office.

Earl Wilson then talked about membership and asked that all members try to bring in a new member.

Peter W. Simmons, national president of the SPE was present at the meeting. When Mr. Simmons was called upon he spoke of the wonderful work being done by the Chicago Chapter, particularly in the educational field.

The meeting was then turned over to Charles Rank, chairman of the program committee. He introduced the guests of the evening all of whom were from the Chemische Werke Huls Aktiengesellschaft, Germany; Dr. Helmut Konig, head of research and development, Hans Kuhrt, export manager and Alfred Travzold, plant engineer. The plant, the largest producer of plastics in Western Europe, is located about 30 miles from Dusseldorf. The main products are polystyrene, polyethylene and polyvinyl chloride. It was originally built to manufacture synthetic rubber and converted to producing plastics after World War II.

Mr. Kuhrt read an article which had been written by Dr. Konig covering the molding of polyvinyl chloride. Two methods of molding polyvinyl chloride were explained in the article; one being injection molding and other transfer molding. The transfer molding being used primarily when molding large parts and heavy sectioned parts.

In injection molding the cylinders used are of a non corrosive material. The cylinder holds 2 to 5 times the weight of the shot and the material is held at 10° to 20° under good flow temperature. The material is injected 20,000 psi and through a restricted opening.

The talk was supplemented by slides showing the various points covered in the article.

After presenting the paper Mr. Kuhrt extended a very cordial invitation to everyone to visit their plant in Germany.

Pioneer Valley

Auxiliary Equipment

William E. Olson

The October meeting of the Pioneer Valley Section was held at the Wachusett Country Club and it featured the discussion of "Auxiliary Equipment" by three speakers.

Bob Yahn of Yahn Engineering Co. discussed the advantages and types of hopper loaders in use today. His talk pointed out how uniformity of process was conducive to good molding conditions and how these machines contributed toward that end. His narration was accompanied by slides showing the machines in action.

Hopper dryers and their positive contribution toward improved and consistent molding was covered by Mr. R. Thoreson of Thoreson—McCosh, Inc. His discussion included improvements noted when non-hydroscopic as well as hydroscopic materials were subjected to drying action and the problems encountered when certain materials were dried during days having high temperatures combined with high humidity.

The final speaker of the night was Mr. John Thompson of New England Engineering and Manufacturing Co. who covered weigh feeders. He showed how they have advanced since they were first introduced on the market and pointed out how the invention of the compensator has been a major factor to their increased effectiveness. Mr. Thompson also pointed out following the manufacturers instructions to the fullest will result in maximum performance of the machine.

Northern Indiana

Sales Development Of New Products

Leon J. Page

The first get-together of the 1957-1958 season for the Northern Indiana Section of the S.P.E. was held at the Chamber of Commerce in Ft. Wayne, Ind. Mr. Leon Page, president, presided over the short business meeting that preceeded the entertainment provided for the meeting. Much of the happenings of the National S.P.E. during the summer months were discussed and the correspondence received was brought to the attention of all. A brief report of National activities was given by Wayne I. Pribble, National committeeman. Mr. Steve Michalski was named by the president to be the new chairman of the credentials committee for the 1957-1958 season. The need for an active organization and enlisting new members was next discussed with basic plans being laid to further this phase of activity.

Mr. Donald Moritz, Manager of Plastics Sales for the United States Rubber Co., was introduced to the members and guests by the president. Mr. Moritz maintains his office at the Fort Wayne Plant of the U. S. Rubber Co. and makes his home in the adjacent town of Cedar Shores, Indiana.

The subject of Mr. Moritz's talk for the evening was "Technical Sales development of New Plastics Products" and he verbally outlined the way in which sales personnel shaped their campaigns around the technical developments of the past, taking advantage of a useful property designed into a material or a product to further sales gains. Also, he showed the important position held by sales personnel in liaison between the customer in need and the people in research who try to fill the needs and requirements.

In his talk, Mr. Moritz went on to prove that scientific acumen and economic "horse sense" were invaluable to sales activity to prevent wasted time and effort on projects of an unsound nature scientifically or of limited remunerative value. Mr. Moritz stated that the basic purpose of engineering organizations, such as the S.P.E., was to accelerate the exchange of scientific information and technical data but that all concerned should not lose sight of the fact that all work in plastics technology must be closely coupled with the commercial aspects of the situation so that financial justification for any effort invested could be demonstrated.

The formal closing of the meeting was called by the president to permit the members to refresh themselves with their favorite beverages and snacks while the speaker was asked to comment on various questions.

Southern California

High Density Polyethylene

John A. Stahmann

Both the physical properties and the industrial applications of high density polyethylene were discussed during the October meeting of the Southern California Section. Mr. W. O. Bracken, who presented the program, is a past president of the Society of Plastics Engineers and a National Director. He has been associated with the development of high density polyethylene at the Hercules Company, Wilmington, Delaware, and thus is unusally well informed on the subject.

About a dozen companies are now engaged in the production of high density polyethylene. By 1960 it is expected that some four hundred million pounds will be produced.

The usual type of polyethylene may be pictured as having many side chains or branches that prevent compaction. The high density material, having about 10% fewer side chains, thus has a higher density and correspondingly different physical properties. The Rockwell hardness, flexural strength, tensile strength, and meeting point are higher. It is quite chemically resistant and also withstands abrasion well.

One of the greatest problems connected with the processing of high density polyethylene is the scalloping or warpage due to high mold shrinkage. Another problem is the notch sensitivity. Nevertheless, a wide range of toys, sports gear, laboratory ware, packaging containers, household ware, grease containers, and cable coverings have been made.

It is readily vacuum formed. The high density polyethylene retains heat so deep draws are possible. In fact, a water fog may be necessary to cool the ware after fabrication.

Southern

C-11 Styrene

R. E. Welch & E. O. Redwine

The Southern Section meeting was held Monday night, October 21, at the Architects' and Engineers' Institute Building. Preceding the meeting, the Board of Directors and Committee Chairmen discussed methods of improving quality of meetings as well as increasing attendance. It was also decided to hold a Christmas party some time in December.

The speaker for the regular meeting was Mr. L. A. Murphy, Technical Representative, Molding Materials Division, Bakelite Company. Mr. Murphy's subject was Bakelite's C-11 styrene acrylonitrile copolymer. He compared this material to general purpose and high impact styrenes and gave us data to show that physical properties of this material are considerably better than normal styrene materials (25-100% better). Cost-wise, C-11 is 60% more expensive than general purpose styrene and about 25% more than high impact styrene on a pound-per-pound basis. C-11 is molded at temperatures between 425°F and 550°F, with the mold temperature between 140 and 190°F. Molding pressures run approximately twice those of general purpose styrene. C-11 is dry colored like other conventional molding materials. It has a heat distortion point of around 200°F and is a tougher material than normal styrene materials. It is recommended for outdoor use up to about 24 months. Mr. Murphy showed us several samples of finished products made from C-11 which demonstrated its excellent strength, clarity and chemical resistance.

The Southern Section Educational Committee is becoming very active in encouraging our Science students in the study of plastics. Several talks have either been made or scheduled before student chapters of engineering societies in the area, to further this interest.

Binghamton

'Inside The Mold'

L. N. Chellis

The Binghamton Section held its monthly dinner meeting at Pee Tee's Restaurant on October 24.

Fifty members and guests turned out to hear Mr. William Rittenhouse of Dow Chemical Company discuss "Inside the Injection Mold with Polystyrene and Polyethylene".

Guests at the meeting included Joseph Cianflone, General Textile Corporation; Leonard Bobonis, Capitol Records; Cyril Lewis, Consolidated Molded Products; Tom Whitney, Spencer Chemical Company; Raynor Hankinson and John Lem, IBM Corporation, Bob Whelan and Tom Ackerly, Brilhart Plastics Company; and Joe Taylor, Ansco Corporation.

Frank Reynolds, National Councilman, reported on the most recent National Council meeting. Highlights were the appointment of our new Executive Secretary, Mr. Thomas Bissell, the planned appointment of Dr. Day as fulltime editor of the SPE Journal, a new cover design for the Journal, and status of the new member drive. Mr. Reynolds also explained for the benefit of the group the procedures to be followed according to the By-Laws for election of our new section directors.

Mr. Rittenhouse discussed flow in injection molding under various cycling conditions. He featured his presentation with two movies made in Dow's Midland Laboratories. Utilizing their photo-mold with glass plate side-walls, high speed photos were made during injection cycles.

Interesting differences were apparent between the plastic fronts of polystyrene and polyethylene. The group was able to see the visual effect on jetting and packing of such variables as ram speed, pressures, and gate size and shape.

The interest of the group was evidenced by the extended discussion from the floor that followed Mr. Rittenhouse's presentation.

Presiding for this meeting was Leroy Chellis, Secretary.

West New England

Automatic Molding

C. Judd Holt

John J. Vollertsen was guest speaker for the section's "Automatic Molding Night" on November 6, when 105 members and guests attended the regular monthly dinner meeting at Betty's Towne House in Agawam, Mass.

Vollertsen, who is employed as a design engineer at Eastman Kodak Company's "Kodak Park" plant in Rochester, N. Y., discussed automatic molding techniques practiced by his firm and described how a relatively high degree of automation has been achieved.

Vollertsen also showed a 40-minute movie which was filmed on the molding floor of the Rochester location. A spirited question-and-answer period followed.

In the business session of the meeting national director George W. Martin (Holyoke Plastics Corp.) reported on what had transpired at the October 10 meeting of the national council at Kansas City.

Martin, who is also national administrator for the society's professional activities groups, introduced Thomas A. DeMarco (Monsanto Chemical Company) to bring the membership up to date on the work of the section's professional activities committee.

DeMarco, who is section P. A. C. chairman, briefly outlined his committee's plans. He reported that a questionnaire already in the mail would help determine in which of 11 areas each section member is interested in participating nationally and/or at section level.

Lawrence W. Freeman (Plax Corporation), chairman of the membership committee, also spoke briefly. He announced that 17 new members had been recruited to bring section membership up to 228.

Armand J. Vallieres (Pro-Phy-Lac-Tic Brush Company) was technical chairman.

New York

High Temperature Reinforced Plastics

Malcolm Riley

Over 125 members and guests turned out recently for a dinner meeting of the Reinforced Plastics Group of the New York Section to hear a symposium on High Temperature Reinforced Plastics. The meeting was held at Tufaro's Restaurant in Corona, Long Island.

Keynoting the symposium, R. T. Schwartz, Chief of the Organic Materials Branch of the Materials Laboratory of Wright Air Development Center, roughly outlined Air Force requirements for higher temperature reinforced plastics of the future. His introductory talk was followed by discussion of the most recent developments in polyesters, silicones, phenolics and epoxies for high temperature use.

Dr. R. G. Nelb of Naugatuck Div., U. S. Rubber Co. described some of the results of their most recent work on high temperature polyesters, which has resulted in the development of Vibrin, 135, 136 and X-1068. The most heat resistant monomers developed by Naugatuck to date have been triallyl cyanurate and diallyl carbate.

Vibrin 135 is a maleic anhydride-modified polyester resin with triallyl cyanurate as the monomer. It can be cured in a variety of ways and parts can be fabricated by any of the conventional techniques used for reinforced plastics. It is normally reinforced with glass fabric with a Garan or 301 finish. The material has been approved under MIL-E-25042 (USAF).

Some properties of a 12 ply 181-Garan laminate with a resin content of 38% are given below:

Ten Str, psi	
R. T.	58,800
30 day immersion (H_2O)	53,100
½ hr at 500 F	40,000
192 hr at 500 F	17,900
Flex Modulus, 10^6 psi	
R. T.	3.06
½ hr at 500 F	2.55
192 hr at 500 F	2.34
Ten Str, psi	
R. T.	38,100
½ hr at 500 F	23,100
Compressive Str, psi	
R. T.	45,000
½ hr at 500 F	30,000

The newest Naugatuck resin about to be announced commercially is Vibrin 136, which has improved high temperature strength and better resistance to oxidation and crazing at high service temperatures. Some typical properties of a 12 ply 181-301 laminate are given below:

Flex Str, psi	
R. T.	57–70,000
192 hr at 500 F	28–33,000
½ hr at 600 F	21,500
½ hr at 700 F	10,600
Flex Modulus, 10^6 psi	
R. T.	3.0–3.9
192 hr at 500 F	2.1–2.4
Ten Str, psi	
R. T.	66,000
30 day immersion (H_2O)	54,600
Compressive Str, psi	
R. T.	53,100
½ hr at 500 F	33,500

Dr. T. F. Hart, Silicone Div., Union Carbide Corp., discussed the two areas in which these semi-organic materials are used in reinforced plastics. First as a resin binder for glass cloth or mat, and second as a high temperature finish for the glass to improve the bond between the glass and organic resins.

Dr. Hart outlined as the outstanding properties of silicone resins: thermal stability, good electrical properties and resistance to water, chemicals, corona and weathering. In discussing the properties of laminates made with GLSA 5973, Bakelite's best resin for production of reinforced silicone laminates, Dr. Hart pointed out that though the mechanical properties of these laminates are not as good as those reported for some organic resin laminates, electrical properties are outstanding, particularly in regard to arc resistance (180-250 sec) and power factor (0.003-0.015 at 1 megacycle). Also, mechanical properties of silicone laminates improve on aging at temperatures of about 500 F for 100 to 500 hr. The primary feature of these laminates in applications such as high speed, high temperature aircraft and missiles is the relatively low rate of degradation where short-term exposure is involved.

Silicones or silanes used as a glass finish contain reactive vinyl or amino groups. Such types are represented by UCC's A-172 and Garan finishes. Such silanes or silicones react with or are stronger adsorbed by the glass surface, while the organically reactive group reacts with the organic resin binder, forming a sort of giant molecule composed of glass-silicone-organic resin.

Mr. Elmer Warnken of Cincinnati Testing Laboratories described the chemistry of phenolics and outlined some of the newer approaches toward using phenolics at higher temperatures. Mr. Warnken pointed out that in some applications phenolic laminates have retained serviceable design properties for as long as 200 hr at 600 F.

Two of the most interesting directions in development are "the development of phenol silanes for use in the 600 F temperature range" and the "controlled failure" or "ablation" theory of design. The ablation theory recognizes that such materials as reinforced plastics retain useful design properties for certain periods of time at temperatures much higher than those at which they can be used continuously. Thus, in certain applications where service is limited to specifically defined durations, reinforced plastics can be used at much higher temperatures than is usually considered feasible. For example, phenolic laminates are used as liners for rocket motors. Combustion temperatures may reach values of 5-7000 F, but the duration of combustion may be only seconds or fractions of seconds. During combustion the phenolic laminate is destroyed, but since the duration of exposure is so short, the laminate retains the strength and thermal insulating value long enough to serve its design purpose in the rocket. By using this design approach, designers and engineers can make use of reinforced plastics in many applications which otherwise might be considered completely out of the realm of plastics.

Though there has been much talk of glass-reinforced phenolic stator blades for jet engines, Mr. Warnken pointed out that all of this work has been developmental to date. He predicted, however, that use of such materials in both stator and rotor blades should be commercial within the next 6 mo.

Mr. John M. Thomas of Resins & Chemicals Div., Jones-Dabney Co., Div. of DeVoe & Reynolds Co., Inc. outlined the potentials for epoxy resins in high temperature reinforced plastics. He pointed out that epoxies are pretty much limited to temperatures up to 300-500 F, and that flexural strength values do not exceed about 12-14,000 psi.

At temperatures above 500 F, use of anti-oxidants in the resin formulation improves design properties. Two materials which are still in developmental stages, but which hold some promise are Shell X-131 and epoxy-phenolic blends.

Who's Who

Biographies of some National Officers of the Society of Plastics Engineers, Inc. are included in Volume X "Who's Who In Commerce and Industry", released this month by A. N. Marquis Company. Haiman S. Nathan, Buffalo Section and National Vice-President; Robert K. Gossett, Chicago Section-National Treasurer and Jules Lindau III, are sketched in the publication.

One hundred per cent attendance was achieved on October 18th, when all nine members of the National Meetings Committee were able to attend the semi-annual committee meeting in North Canton, Ohio.

As the above picture was taken, the Meetings Committee was receiving a report from Ross Dean, Chairman, Speakers' Sub-Committee, concerning the "Technical Speakers' List" distributed to Section officers this month. Other projects discussed under the leadership of dynamic Frank A. Martin, Chairman, were the "ANTEC and RETEC Procedures Manual" which was published during November; the S.P.E. program for Regional Technical Conferences (RETEC) for 1958; and the award of the 1963 Annual Technical Conference (ANTEC) to one of the seven Sections bidding to sponsor this event..

Committee members are (reading clockwise, left to right) John Picard, Detroit Section; Thomas A. Bissell, S.P.E. Executive Secretary; Don Bowlin, National Director-Toledo Section; Frank A. Martin, Cleveland-Akron Section, Chairman; Ken Gossett, Chicago Section, National Secretary and Administrator, Meetings Committee; Guy Martinelli, New York Section, Co-Chairman, 1959 ANTEC; Ross Dean, Milwaukee Section; and Carl H. Whitlock, Detroit Section, General Chairman, 1958 Annual Technical Conference.

Toledo

House of Future

R. E. Dunham

The annual Ladies' Nite of the Toledo Section was held Wednesday night, Oct. 16, 1957, at Sunningdale Country Club with a large attendance. After a splendid dinner drawings for prizes were held with Mrs. Gerald Minnick winner of the grand prize, a mink stole. Plastic favors were received by all ladies.

Miss Gertrude Bailey of Monsanto Chemical Co. was speaker of the evening and presented the "House of the Future" using beautiful colored slides. She first reviewed the use of plastics in homes of today with emphasis on such items as vinyl floor tile, plastic wall coverings, styrene drawers, synthetic fibers, and other items.

With reference to residential construction the "House of the Future" in Disneyland was used as an illustration of many new uses of plastics in building expected in the next ten years. This futuramic home cost over a million dollars and resulted from the cooperation of twelve companies in a project to display their products. The cantilevered construction is unique and the molded sections probably were never used for making a home previously. Some of the other unusual items were urethane foam insulation, televiewer phone, climate control, electronic oven, ultrasonic dishwasher, flip flop sofa, music wall, melamine cabinets, molded bathroom, and ultra modern furnishings.

One of the future markets for plastics was definitely outlined to the wives of members and guests of the Toledo Section and a pleasant evening was enjoyed by all.

Section Meeting Dates

The correct new meeting dates for St. Louis, Kansas City and Rocky Mountain sections are listed below. This second notice takes account of the fact that the third Wednesday in the month doesn't always follow the third Tuesday!

St. Louis meets the third Tuesday of each month.

Kansas City meets on the Wednesday following the third Tuesday.

Rocky Mountain meets on the Thursday following the third Tuesday.

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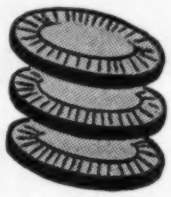

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Abstracts of Conference Papers . . .

(Continued from page 67)

form of unsupported film with good clarity. In order to obtain this tough, rigid film with good barrier properties, heat resistance and clarity, new film extrusion techniques are being studied.

When polyethylene having an initial density of 0.96 is extruded through a flat die at high temperatures and properly quenched, some of the properties required most of a packaging film are enhanced. By thus controlling the crystallinity of the film, substantial improvement can be noted in impact strength and clarity.

Criteria for Mixing and the Mixing Process by J. T. Bergen, Armstrong Cork Company and G. W. Carrier and J. A. Krumhansl, Brown University

Intensive Mixing by Wm. R. Bolen and R. E. Colwell, Monsanto Chemical Company

Thermoplastic polymers are processed in batch and continuous intensive mixers to produce combinations with various fillers, colorants and modifying ingredients. Mixing which depends primarily on the degree of shear is termed intensive mixing. Mixing which depends on the extent of flow occurs simultaneously and is termed extensive mixing. The intensive mixing process discussed in this paper is one in which the particles to be mixed break down into smaller sizes under the influence of shearing stresses greater than can be sustained by the particles without rupturing. If the mixer is operated at lower levels of shearing stress no size reduction occurs and the particles undergo extensive mixing only.

A relationship between the number of particles, the time of mixing, and the shearing stress is proposed. A method for estimating the shearing stress in a basic intensive mixer is presented. Values are computed for a polyethylene resin at several rotor speeds and tip clearances. The importance of thermal control is discussed.

The validity of the simple flow theory is tested by operation of a small scale model. Experimentally determined pressure differences are compared with computed values.

Rheological Considerations in Plastics Product Design by Bryce Maxwell, Princeton University

Although the subject of rheology is most often associated with materials in the liquid state, the flow or deformation characteristics of plastics at use conditions are important criteria for proper application engineering design. A rapid method of determining the time and temperature sensitivity of rheological properties by means of a single dynamic test is presented. The correlation of this rheological data with conventional engineering properties such as impact resistance, hardness and damping capacity is discussed together with interpretation of the results of studies on methyl methacrylate, polyvinyl chloride and polyethylene of both high and low density in terms of engineering design.

"Progress Through Plastics Engineering"
14th Antec See page 56

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tically no reinforcing, but stabilize the surface resin and allow a heavy resin layer to be used. These mats range in thickness from .010 inches to .030 inches and have resinous binders that include treatments for maximum water resistance. Unlike the reinforcing mats, they use filaments of glass that are not collected into bundles. They are made either by the blown fiber process or by mechanical pulling onto a large drum.

The difference between surfacing and overlay mats is basically in the stiffness of the material. Surfacing mats contain enough binder to make them quite strong; consequently, they are rather stiff. As a result, they are useful as a surfacing material only on flat or simply contoured parts. The overlay mats have a small amount of binder so that they are fluffy and extremely drapeable. Although not as easy to handle as the surfacing mats, the overlay mats can be used on complex shaped parts.

Of particular interest to the building industry is that translucent sheets made with surfacing mat over the chopped strand reinforcement have superior weathering properties. This construction is rapidly being adopted by the industry.

Woven Fabrics

These were the first type of reinforcement employed. Although higher in cost than mats, they are widely used because they impart high strengths to moldings.

Many kinds of fabrics and tapes are available. These vary in weight, thickness, style of weaver, coarseness of yarns and glass fiber diameter. Although both continuous and staple yarns are used, the continuous type is most common because of its higher strength. Because of the wide variety of fabrics available, almost any degree of thickness and directional properties can be obtained. Although most fabrics are "square" (that is, an equal amount of glass running in each direction), unidirectional varieties are popular.

Fiberglas cloth and polyester resin are widely used in covering boats to strengthen them and eliminate yearly maintainence. Freight car interiors are upgraded in the same manner. Similar applications can be developed in the building field.

Woven Rovings

These are a relatively new form of fibrous glass reinforcements, but they are becoming increasingly popular because they are thick, give high strengths to a part and are lower in cost than conventional fabrics. Like the conventional fabrics, they are available in a wide variety of weaves.

Also known as "roving cloths", they are made by weaving rovings into coarse, heavy drapeable fabrics. Because they are made from rovings rather than yarns, heat cleaning and finishing is unnecessary; the original size provides satisfactory resin-to-glass adhesion.

Woven rovings may be one of the biggest factors in future reinforced plastics building structures. It lends itself to fabrication of very large structures by the hand layup or vacuum bag molding process. An example of the use of this material in a highly engineered building structure is the Monsanto House of the Future.

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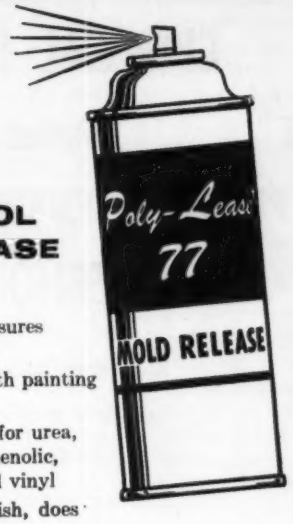

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Economics of the Various Forms

As mentioned in the previous sections, there are significant differences in the costs of the various reinforcing materials. It can be stated generally that those forms which give the highest strength to a reinforced plastic part are the most costly.

The least costly forms (chopped strands, rovings and mats) impart a non-directional strength to the molded part. The more expensive woven materials are highly directional; that is, they give strength in one or two directions only. Therefore, a brief consideration of the strengths of panels would show that the woven materials are a much more efficient reinforcement.

However, this can be misleading because the strength of a part made with non-woven reinforcements is spread in all directions (in many cases this is highly desirable). Also, the glass content of a part has a prime effect on the strength and, because of their geometry, woven reinforcements give substantially higher glass content than non-woven reinforcements.

Nevertheless, on a cost per pound basis, a breakdown of the materials will show the woven fabrics, yarns and surfacing overlay mats to be the most expensive. The woven rovings and milled fibers are less costly. The reinforcing mats are substantially low cost reinforcements, while rovings and chopped strands are the lowest cost form available.

There are many reinforcements available for plastics. Each material offers a particular combination of handling characteristics, degree of reinforcement and economics. Thus, choice of reinforcement has great bearing on the successful design of a reinforced plastic molding. (Table 1). ★ ★

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Graft Copolymers

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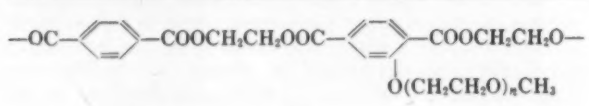
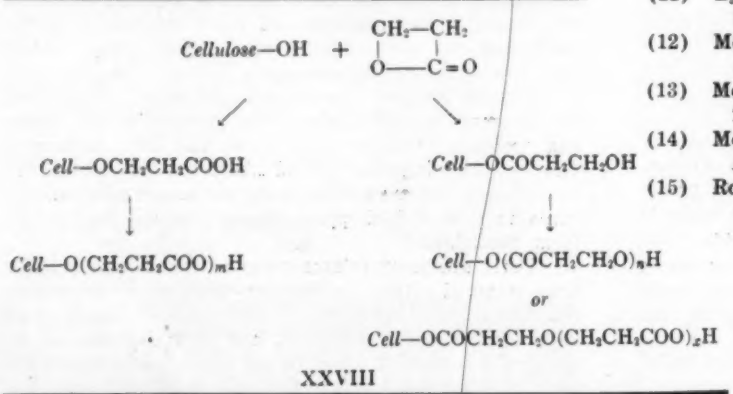
with polyethylene terephthalate possessing the structure given below (XXVII).



XXVII

The reaction of cotton with β-propiolactone yields graft polymers as a result of etherification and polyesterification. The polymers are mixed ethers and esters of cellulose due to the further reaction of the initial products with the lactone (XXVIII) *(5)*. The ether linkages are stable to saponification while the ester linkages are broken. Therefore, saponification removes all but the carboxyethyl groups attached directly to the cellulose molecule. Dehydration of the β-propiolactone-treated cotton by azeotropically removing water with xylene results in the production of unsaturated groups in the hydracrylic acid ester groups attached to the cellulose molecule (XXIX).



XXVIII

XXIX

Significance

The appendage of sidechains or branches to various natural or synthetic high polymers results in the formation of a composite macromolecule whose properties generally differ from those of the individual components. The preparation of a graft copolymer represents a method of tailor-making a polymeric molecule in order to incorporate desired characteristics. It yields a new tool to be used in the task of controlling and molding molecular structure. ★

(Part two of this article will appear next month.)

References

(1) Angier, D. J., and Watson, W. F. *J. Polymer Sci., 18*, 141 (1955); *20*, 235 (1956).

(2) Ballantine, D. S., Glines, A., Metz., D. J., Behr, J., Mesrobian, R. B., and Restaino, A. J., *J. Polymer Sci., 19*, 219 (1956).

(3) Bevington, J. C., Guzman, G. M., and Melville, H. W., *Nature, 170*, 1026 (1952).

(4) Bloomfield, G. F., and Swift, P. M., *J. Appl. Chem. (London), 5*, 609 (1955).

(5) Daul, G. C., Reinhardt, R. M., and Reid, J. D., *Textile Research J., 24*, 738 (1954); *25*, 330 (1955).

(6) Guillet, J. E., and Norrish, R. G. W., *Nature, 173*, 625 (1954).

(7) Haas, H. C., Cohen, S. G., Oglesby, A. C., and Karlin, E. R., *J. Polymer Sci., 15*, 427 (1955).

(8) Hahn, W., and Lechtenbohmer, H., *Makromol. Chem., 16*, 50 (1955).

(9) Hayes, R. A., *J. Polymer Sci., 11*, 531 (1953).

(10) Jones, M. H., Melville, H. W., and Robertson, W. G. B., *Nature, 174*, 78 (1954).

(11) Lynch, C. S., U. S. Patent 2,625,525 (January 13, 1953).

(12) Merrett, F. M., *Trans. Faraday Soc., 50*, 759 (1954).

(13) Merrett, F. M., and Wood, R. I., *Rubber Chem. & Technol., 29*, 706 (1956).

(14) Metz., D. J., and Mesrobian, R. B., *J. Polymer Sci., 16*, 345 (1955).

(15) Roland, J. R., and Richards, L. M., *J. Polymer Sci., 9*, 61 (1952).

(16) Saigusa, T., and Oda, R., *Bull. Inst. Chem. Research Kyoto Univ., 33*, 126 (1955).

(17) Schmets, J., and Smets, G., *Bull. soc. chim. Belges, 63*, 59 (1954).

(18) Smets, G., and Hertoghe, A., *Makromol Chem., 17*, 189 (1956).

Mark of the Professional . . .

(Continued from page 33)

professions who give their time to teach. The chemical profession could undoubtedly improve its status if chemists themselves would contribute more time to improving chemical training in local technical schools.

No Cog in a Machine

Other characteristics which distinguish the professional man from the "pro" are individual initiative, judgment, and responsibility. A very high portion of the specialized work done by chemists and chemical engineers requires personal responsibility and personal decision.

Intelligent management makes full use of the scientist's judgment and his willingness to assume responsibility. However, this is not apparent to the public. To the outsider chemists and chemical engineers appear as so many cogs in the industrial machine. Unfortunately, sometimes thoughtless industrial managements fail to use technical men in ways which will use and develop their abilities. This is one reason why we are finding it so hard to recruit an adequate number of engineers and scientists.

We have already discussed that phase of professional status involving the acquisition of special knowledge which sets the professional man apart from the man with an ordinary education. However, the professional man must not only have special knowledge, but he must use it to instruct and to serve others. The use of specialized knowledge as service gives the professional man such as a doctor, lawyer, or minister much of the special prestige which he holds in our communities.

The service given by men in these professions is obvious and public, for it goes to individuals themselves. We feel very strongly that the chemist and the chemical engineer deserve such professional status, since they use their special knowledge for the benefit of others, but unfortunately, not as publicly as the doctor or the lawyer. The contributions most of us make to our communities reach them as products marketed by our employers.

As a result, people do not immediately think of improvements in their living standards as services of chemists, but as those of the chemical industry or the "science of chemistry."

The nature of the chemical profession, the type of things chemists and chemical engineers are supposed to do, and the ways in which they must do them present difficulties in achieving the kind of professional status and the public recognition enjoyed by doctors and lawyers. However, many chemists and engineers have not stopped to analyze what is involved in earning the right to the professional status they desire. Many are unwilling to strive for such status. And the education considered necessary for a chemist or engineer has in some ways failed to increase in scope and in nature as rapidly as the complexity of the science has increased. Finally, our young chemists have not been instilled with the desire for a professional status and an understanding of how to achieve it.

The real rock bottom test of whether the chemist or chemical engineer is a professional man or simply a "pro" is the extent to which he recognizes his personal responsibility for the advancement of chemistry and of the professional and social standing of himself and others in his profession. ★ ★

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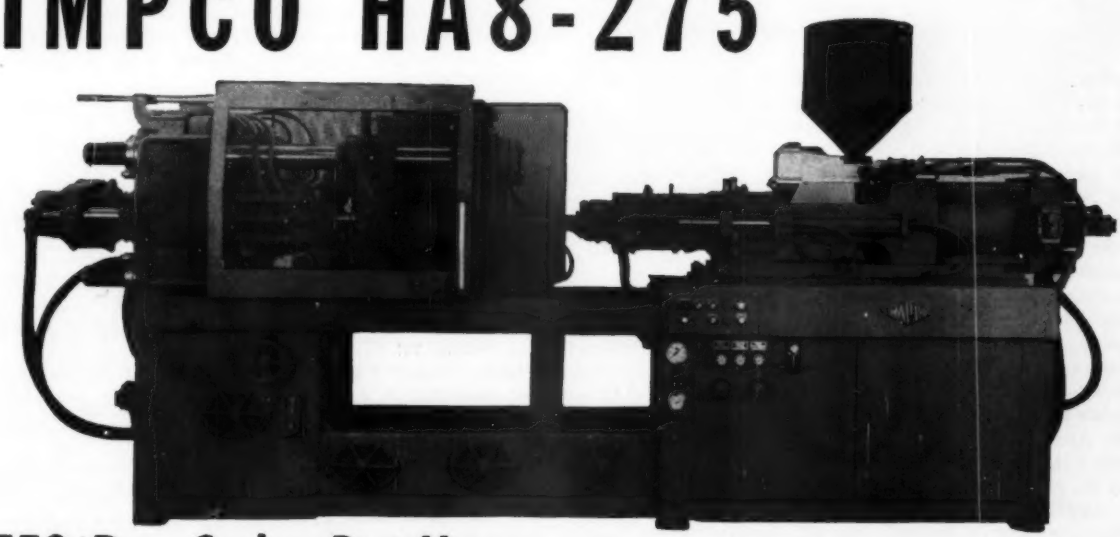

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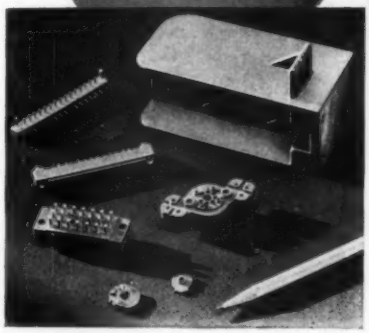

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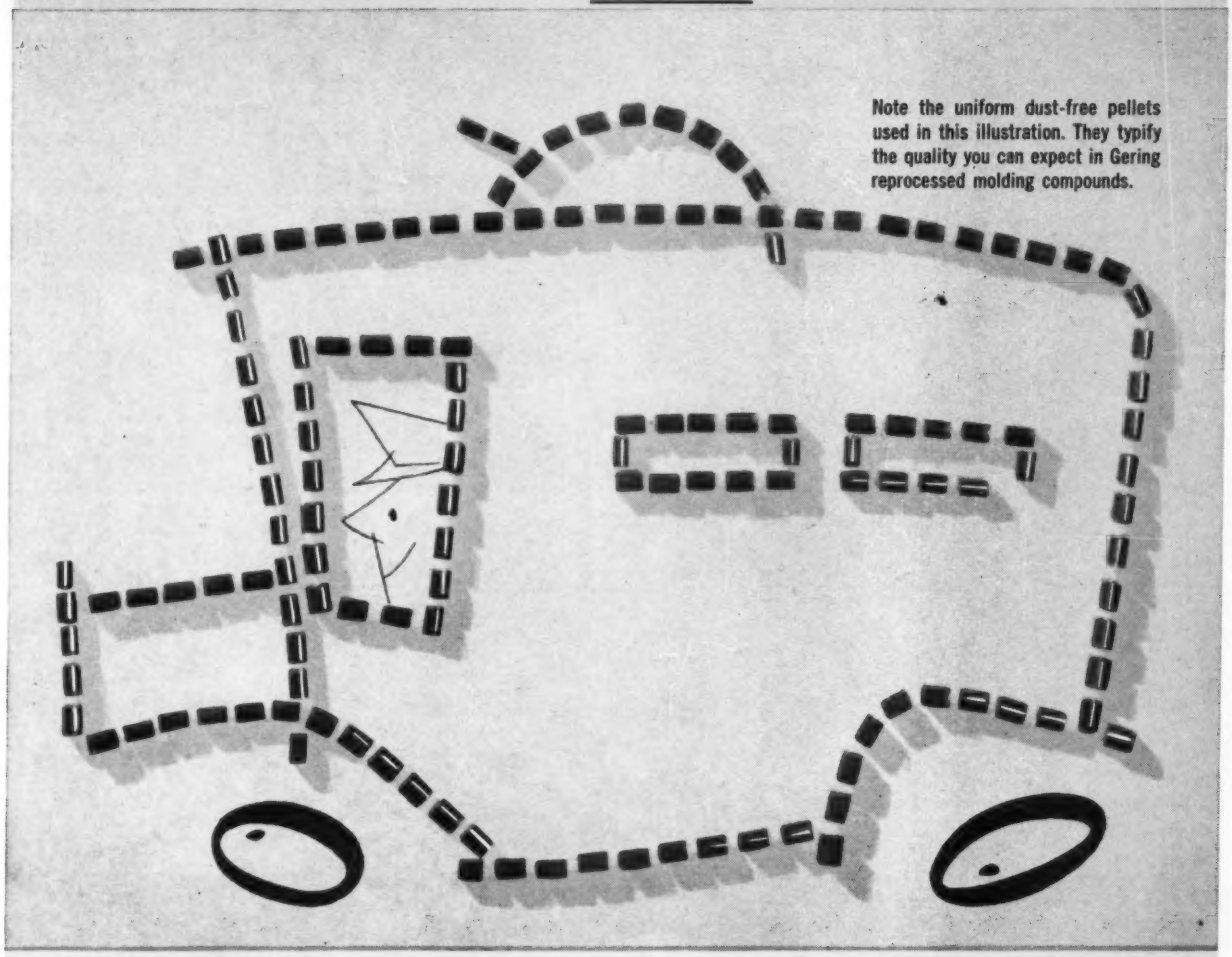

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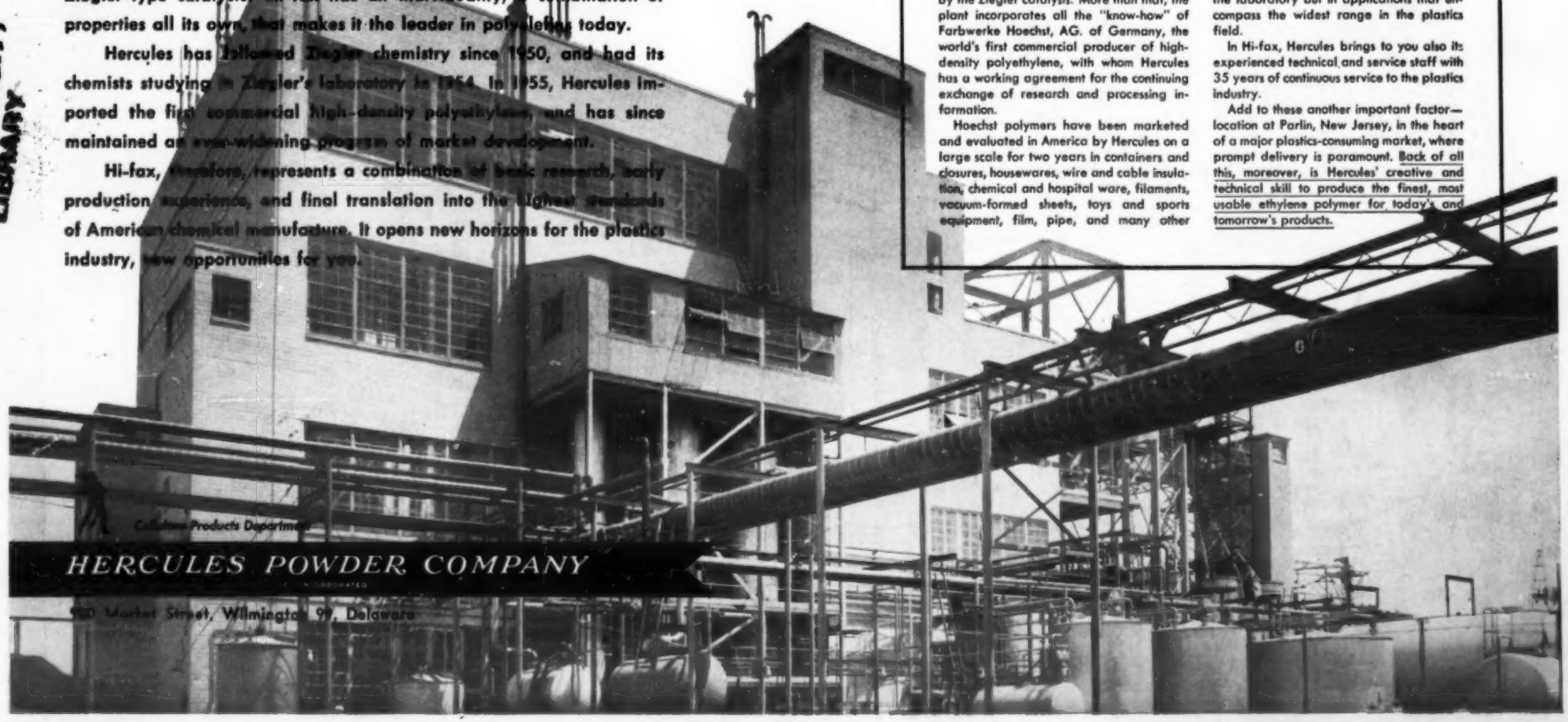

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